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This report contains citations of publications for the years 1979-1982 on research conducted or supported by the Environmental Research Laboratory-Duluth.

All published material has been organized into two major categories: (1) Journal Articles, Book Chapters, Proceedings, etc., and (2) EPA Research Reports. The report is organized by year with all journal articles, book chapters, proceedings, etc., for a given year appearing before the EPA research reports for the same year; within each category publications are listed alphabetically by author.

Authors of the publications listed include ERL-Duluth laboratory staff members and scientists at universities, in industry, and at other facilities who received research funding under the auspices of the Environmental Research Laboratory-Duluth.

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FRESHWATER FINDINGS, 1979-1982

Research Publications of the Environmental Research Laboratory Duluth, Minnesota

Compiled by

Terry Highland
Carolanne Curtis

ENVIRONMENTAL RESEARCH LABORATORY
OFFICE OF RESEARCH AND DEVELOPMENT
U.S. ENVIRONMENTAL PROTECTION AGENCY
DULUTH, MINNESOTA 55804

INTRODUCTION

This report contains citations of publications for the years 1979-1982 on research conducted or supported by the Environmental Research Laboratory-Duluth.

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CONTENTS

Page

Introduction ii

1979 --

Journal Articles, Book Chapters, Proceedings, etc. 1

EPA Research Reports 23

1980 --

Journal Articles, Book Chapters, Proceedings, etc. 35

EPA Research Reports 66

1981 --

Journal Articles, Book Chapters, Proceedings, etc. 99

EPA Research Reports 136

1982 --

Journal Articles, Book Chapters, Proceedings, etc. 144

EPA Research Reports 184

1979

JOURNAL ARTICLES, BOOK CHAPTERS, PROCEEDINGS, ETC.

Andrews, C. B., and M. P. Anderson. 1979. Thermal Alteration of Groundwater Caused by Seepage from a Cooling Lake. Water Resour. Res. 15(3): 595-602.

> Groundwater temperatures in the vicinity of a 200-ha power plant cooling lake in central Wisconsin were monitored in the field for 1 year, and the response of subsurface temperatures to seasonal changes in lake and air temperatures was simulated by means of a mathematical model. The cooling lake, which has been in use since May 1975, when a 500-mw electric generating unit began operation, loses water to the groundwater system at a rate of 2×10^4 m^3/d. The zone of thermally altered groundwater is confined to a relatively small area hydraulically downgradient from the cooling lake. However, the lake is situated in a groundwater discharge area, and changes in subsurface temperatures at depths less than 6 m are believed to have affected the vegetation in the thermally altered zone. The model, which couples equations describing groundwater flow with those describing heat transport in the subsurface, was used to simulate the seasonal temperature fluctuations within seven cross sections oriented parallel to the direction of groundwater flow away from the cooling lake. Simulated temperature patterns agreed well with field data but were very sensitive to the distribution of subsurface lithologies. Results from a predictive simulation suggest that when a second 500-mw generating unit begins operation in 1978, groundwater temperatures will increase less than 5°C at distances greater than 15 m from the cooling lake. The results of this study suggest that the potential for significant thermal alteration of surface water bodies located in groundwater discharge areas is slight.

Broderius, S. J., and L. L. Smith, Jr. 1979. Lethal and Sublethal Effects of Binary Mixtures of Cyanide and Hexavalent Chromium, Zinc, or Ammonia to the Fathead Minnow (Pimephales promelas) and Rainbow Trout (Salmo gairdneri). J. Fish. Res. Board Can. 36(2): 164-172.

> Various models have been proposed to predict the combined interactive effect on fish of mixtures of poisons from separate toxicities of individual substances. The success of these models was tested, using data describing the lethal and sublethal effects of individual substances or binary mixtures of HCN and Cr(VI), Zn(II), or ammonia to the fathead minnow (Pimephales promelas) and rainbow trout (Salmo gairdneri). Using the strictly additive toxic unit and additive index approach, it was determined from log-dosage mortality curves that the Zn-HCN and ammonia-HCN mixtures were more acutely toxic and Cr-HCN less toxic than predicted. The concentration and response addition models, which have been proposed for toxicants whose joint action is similar or independent, respectively, could not be used to predict dosage-mortality curves for the HCN mixtures. Linear regression lines representing the

growth response of fish to log concentration for toxicants alone and in binary combinations were not significantly different. Thus, for the toxic substances tested, the sublethal joint action of individual toxicants was not predictable from existing models and, in most cases, no interaction was indicated. The interactive nature of toxicants may be a function of the concentrations tested causing different biological processes to be affected (e.g., mortality vs. growth), and therefore different responses to be measured. A need still exists for development of a valid multiple toxicity approach for evaluating and predicting the toxicity of chemical combinations.

Caple, R. 1979. Trihalomethane Levels in the St. Louis Estuary of Lake Superior: A Monitor of Chloro-organics as a Source of Taste and Odor Problems in Fish. IN: Third Conference on Water Chlorination: Environmental Impact and Health Effects. Colorado Springs, Colorado, October 28 - November 2, 1979.

A major step was taken in 1979 to decrease the point sources of industrial and domestic pollutants on the St. Louis estuary of Lake Superior by the start-up of the Western Lake Superior regional sewage treatment plant (WLSSD) in Duluth. One significant objective of this regional plant was to recover the vast St. Louis estuary as a viable fish spawning and sport fishing area. The regional plant treats all major effluents, most notably those from the city of Cloquet and its paper mills, upstream from the estuary itself.

The purpose of this study was to evaluate the impact of WLSSD on chloro-organic levels in the estuary from two points of view. One is the "clean-up" of the river and estuary from Cloquet to the new point source of chloro-organics, the effluent of WLSSD itself. Thus it naturally follows that a second aspect of this study would be to evaluate the impact of moving the point sources of chloro-organics to a single new location at the head of the estuary, i.e., the WLSSD plant.

The analysis of haloforms has shown a significant decrease in solubilized chloro-organics in the St. Louis estuary, including the fertile spawning area of Fond du Lac. This decrease (of the order of magnitude of ten-fold) correlates quantitatively with the improved taste of walleyes caught in the estuary, especially in the early part of the summer.

On the other hand this promising improvement is tempered by the fact that the haloforms levels are not yet zero (of the order of 2 ppb) and probably will have a significant background level for years as the sediments equilibrate with the aqueous environment. Furthermore, alarming quantities of THM's are being released in the effluent of WLSSD into the head-waters of this estuary. These quantities of THM's reflect the organic content of the industrial influent to WLSSD and the resulting high chlorine demands at the disinfection stage.

Chakoumakos, C., R. C. Russo, and R. V. Thurston. 1979. Toxicity of Copper to Cutthroat Trout (*Salmo clarki*) Under Different Conditions of Alkalinity, pH, and Hardness. Environ. Sci. Toxicol. 13(2): 213-219.

Median lethal concentration (96-hr LC50) values for acute copper toxicity to 3-10 g cutthroat trout (*Salmo clarki*) have been determined for nine different combinations of alkalinity, hardness, and pH. Equilibrium calculations were performed on the copper LC50 values; seven different soluble species of copper were considered: Cu^{2+}, $CuOH^{+}$, $Cu(OH)_2^{0}$, $Cu_2\text{-}(OH)_2^{2+}$, $CuHCO_3^{+}$, $CuCO_3^{0}$, and $Cu(CO_3)_2^{2-}$. The acute toxicity of copper was inversely correlated with water hardness and alkalinity. At a given alkalinity, hardness determined the LC50; at a given hardness, alkalinity determined the LC50. At a given alkalinity and hardness, the concentrations of the copper species were determined by the pH of the water. Under the conditions tested, Cu^{2+}, $CuOH^{+}$, $Cu(OH)_2^{0}$, and $Cu_2(OH)_2^{2+}$ were toxic forms of copper to cutthroat trout; $CuHCO_3^{+}$, $CuCO_3^{0}$ and $Cu(CO_3)_2^{2-}$ were not toxic. Results of 11 96-hr copper toxicity bioassays on 1- to 26-g rainbow trout (*Salmo gairdneri*) under uniform water chemistry conditions are also reported.

Cook, P. M. 1979. Preparation of Extrapulmonary Tissues and Body Fluids for Quantitative Transmission Electron Microscope Analysis of Asbestos and Other Mineral Particle Concentrations. IN: Annals of the New York Academy of Sciences, Volume 330, pp. 717-724. ERL-D Reprint #224.

The preparation of tissue and body fluid samples is a critical step in the determination of microscopic particle concentrations and characteristics by electron microscopy. A critical review of tissue preparation techniques reported in the literature is provided with emphasis on analytical sensitivity and accuracy and the problem of particle contamination. Details of a method devised for analysis of mineral fibers in urine samples are provided as an example of how the basic requirements for insuring quantitative particle analysis are achieved.

Cook, P. M., and G. F. Olson. 1979. Ingested Mineral Fibers: Elimination in Human Urine. Science 204: 195-198. ERL-D Reprint #206.

Sediments in human urine examined by transmission electron microscopy contains amphibole fibers which originate from the ingestion of drinking water contaminated with these mineral fibers. The ingestion of filtered water results in the eventual disappearance of amphibole fibers from urine. These observations provide the first direct evidence for the passage of mineral fibers through the human gastrointestinal mucosa under normal conditions of the alimentary canal.

Delumyea, R., and R. L. Petel. 1979. Deposition Velocity of Phosphorus-Containing Particles Over Southern Lake Huron, April-October, 1975. Atmos. Environ. 13: 287-294.

> Total mass, phosphorus concentration and the size distribution of phosphorus containing particles were determined. Samples were collected aboard the R/V Roger R. Simons and at eleven land-based stations from April to October, 1975. Based on cross-lake mass and phosphorus concentration gradients, size distribution and vertical profiles, a mixing box model was used to determine a deposition velocity for phosphorus-containing particles of 0.57 cm s^{-1}.

DePinto, J. V. 1979. Water Column Death and Decomposition of Phytoplankton: An Experimental and Modeling Review. IN: Perspectives on Lake Ecosystem Modeling, Chapter 2 (D. Scavia, and A. Robertson, eds.), pp. 25-52, Ann Arbor Science, Ann Arbor, Michigan.

> The purpose of this chapter is to discuss the bacteria-mediated decomposition of phytoplankton and phytoplankton-related organic matter and the subsequent remineralization of algal growth-regulating nutrients such as phosphorus and nitrogen in terms of our inadequate understanding of those processes and the resultant failure by modelers to describe them adequately. This chapter reviews the experimental literature and the latest attempts by modelers to respond to this evidence in building submodels for death and decomposition of algae in the water column. In addition, suggestions are forwarded for needed experimental study of the process. It is hoped that this review will spawn new experimental research aimed at quantifying these processes.

Diehl, S. R., D. T. Smith, and M. Sydor. 1979. Analysis of Suspended Solids by Single-Particle Scattering. Applied Optics 18(10): 1653-1658.

> Light scattering by individual particulates is used in a multiple-detector system to categorize the composition of suspended solids in terms of broad particulate categories. The scattering signatures of red clay and taconite tailings, the two primary particulate contaminants in western Lake Superior, along with two types of asbestiform fibers, amphibole and chrysotile, were studied in detail. A method was developed to predict the concentration of asbestiform fibers in filtration plant samples for which electron microscope analysis was done concurrently. Fiber levels as low as 5×10^4 fibers/liter were optically detectable. The method has application in optical categorization of samples for remote sensing purposes and offers a fast, inexpensive means for analyzing water samples from filtration plants for specific particulate contaminants.

DiToro, D. M., and W. F. Matystik, Jr. 1979. Phosphorus Recycle and Chlorophyll in the Great Lakes. J. Great Lakes Res. 5(3-4): 233-245.

> The recycle rate of unavailable to available phosphorus for the Great Lakes is related to the chlorophyll concentration of the basin. Two types of evidence are presented: the observed decline in the ratio of unavailable to total phosphorus with increasing chlorophyll concentration together with an analysis of these data based on simplified steady-state kinetic equations; and, second, the results of seasonal phytoplankton calculations for Lake Huron, Saginaw Bay, and Lake Ontario. Consistent agreement is achieved with the same phytoplankton and recycle kinetic constants if the recycle rate is assumed to be a saturating function of chlorophyll. Unlike the behavior of models with constant recycle rate coefficients, the calculated effect of percentage increases in phosphorus mass discharges are greater than a proportional percentage increases in chlorophyll concentration for the lower range of chlorophyll concentrations. This positive feedback mechanism is of practical importance with regard to lake management decisions. Computed results for Lake Huron are a dramatic illustration: a two-fold increase in phosphorus discharge results in an almost four-fold increase in algal chlorophyll.

Eisenreich, S. J., G. J. Hollod, and T. C. Johnson. 1979. Accumulation of Polychlorinated Biphenyls (PCBs) in Surficial Lake Superior Sediments. Atmospheric Deposition. Environ. Sci. Technol. 13(5): 569-573.

> Sediment cores were obtained from Lake Superior by means of an oceanographic box corer and analyzed for polychlorinated biphenyls (PCBs). Concentration of PCBs in the top 0.5 cm averaged 0.17 ± 0.13 μg/g of sediment on a lakewide basis. The maximum PCB concentrations were found in surficial sediments between the Keweenaw Peninsula and Thunder Bay in the prevailing downward direction of Thunder Bay, Ontario. Depth-fractionated sediments yielded no detectable PCBs at depths greater than 3 cm below the sediment-water interface, and they often were not detected below a burial depth of 1 cm. The depth of sediment turbation by biotic or physical processes appears to be less than 1 cm. PCB input to Lake Superior from the atmosphere (dry, wet, gaseous) is estimated as $3\text{-}8 \times 10^6\ \mathrm{g \cdot year^{-1}}$, and can account for sedimentary PCB concentrations. The PCB sedimentation rate in Lake Superior is estimated as $\sim 0.3\text{-}0.4\ \mu\mathrm{g \cdot m^{-2} \cdot year^{-1}}$. The results of this study suggest that atmospheric transport and deposition may dominate PCB input to the Lake Superior ecosystem.

Elcombe, C. R., and J. J. Lech. 1979. Induction and Characterization of Hemoprotein(s) P-450 and Monooxygenation in Rainbow Trout (*Salmo gairdneri*). Toxicol. Appl. Pharmacol. 49: 437-450.

Hepatic microsomes obtained from control rainbow trout showed relatively low monooxygenase activities toward benzo[a]pyrene, ethoxycoumarin, ethoxyresorufin, and ethylmorphine as substrates. However, benzo[a]pyrene hydroxylation, ethoxycoumarin-O-deethylation, and ethoxyresorufin-O-deethylation were greatly induced by pretreatment of trout with β-naphthoflavone and Aroclor 1242. No increase in ethylmorphine-N-demethylation, liver/body ratio, or yield of microsomal protein were observed. Phenobarbital pretreatment of trout failed to affect any of the parameters studied. The λ_{max} of carboxyferrocytochrome P-450 was at 449 nm in control microsomes, and although a small (40%) increase in total hemoprotein(s) P-450 was seen after β-naphthoflavone pretreatment no hypsochromic shift of the λ_{max} was observed. No significant changes in the 430/455 ratio of the EtNC ligand spectra were noted after induction. Type I and Type II binding spectra were observed in all microsomal preparations examined. The use of specific inhibitors of monooxygenation (α-naphthoflavone and metyrapone) indicated that control and induced trout hepatic hemoprotein(s) P-450 were similar to rat cytochrome P_1-450. Furthermore, sodium dodecyl sulfate-polyacrylamide gel electrophoresis demonstrated the presence of a novel hemoprotein in hepatic microsomes after pretreatment of trout with β-naphthoflavone or Aroclor 1242. This induced protein had a molecular weight of approximately 57,000.

Elcombe, C. R., R. B. Franklin, and J. J. Lech. 1979. Induction of Hepatic Microsomal Enzymes in Rainbow Trout. IN: Pesticide and Xenobiotic Metabolism in Aquatic Organisms (M. A. Q. Kahn et al., eds.), pp. 319-337, American Chemical Society Symposium Series No. 99.

This paper presents the results of studies toward examining the interaction of chemicals with the hepatic microsomal monooxygenase system of fish and to determine whether multiple forms of hemoprotein(s) P-450 exist, and, if so, how the relative microsomal hemoprotein subpopulations are altered by xenobiotics.

The results suggest that rainbow trout are responsive to cytochrome P_1-450-type inducers (e.g., planar polychlorinated biphenyls and polycyclic aromatic hydrocarbons), but are not responsive to cytochrome P-450-type inducers (e.g., phenobarbital and non-planar polychlorinated biphenyls). Although induced rainbow trout hemoprotein(s) P-450 show high activity with cytochrome P_1-450 substrates, the induced hemoprotein at 57,000 daltons appears, in electrophoretic and spectral properties, to differ from rodent cytochrome P_1-450.

Guiney, P. D., M. J. Melancon, Jr., J. J. Lech, and R. E. Peterson. 1979. Effects of Egg and Sperm Maturation and Spawning on the Distribution and Elimination of a Polychlorinated Biphenyl in Rainbow Trout (*Salmo gairdneri*). Toxicol. Appl. Pharmacol. 47: 261-272.

Distribution and elimination of 2,5,2',5'-tetrachloro[^{14}C]biphenyl (4-CB) were studied for 1 year after exposing female and male rainbow trout to the compound in water and then transferring the fish to a hatchery raceway. The fish were exposed in December, weights of the maturing eggs and sperm began to increase in June, and the fish began to spawn in October. From January through August elimination of 4-CB was slow with a t 1/2 for whole body elimination of 1.76 years in females and 1.43 years in males. However, during the spawning season whole body elimination was more rapid in both sexes; t 1/2 = 0.52 year in females and 0.54 year in males. The increased elimination rate appeared primarily to be due to the voiding of 4-CB containing eggs and sperm as opposed to enhanced elimination of 4-CB from extragonadal tissues. Prior to the enhanced elimination there was a redistribution of 4-CB residues within the fish's body. This was characterized by a depletion of 4-CB from eyes and periorbital fat, followed later in time, by a reduction in 4-CB content of visceral fat. Temporally related to this was an accumulation of 4-CB residues in maturing eggs and sperm. Thus, redistribution of 4-CB occurred during spermatogenesis and vitellogenesis and preceded the enhanced elimination of 4-CB from the whole fish when the gametes were spent from the body. The overall significance of this study is that it underlines the enhancing effect of egg and sperm maturation and spawning on whole body elimination of polychlorinated biphenyls in fish.

Hall, R. J., and G. E. Likens. 1979. Ecological Effects of Whole-Stream Acidification. IN: Atmospheric Sulfur Deposition: Environmental Impact and Health Effects, Chapter 43 (D. S. Shiner et al., eds.), pp. 443-451, Ann Arbor Science, Ann Arbor, Michigan.

A natural mountain stream was experimentally acidified to determine the effects on abiotic and biotic parameters. Sulfuric acid was added in dilute concentrations to Norris Brook within Hubbard Brook Experimental Forest. Stream water pH was lowered to 4.0 for five months in 1977. Increased acidity resulted in significant mobilization of Al and Ca in the stream water. Mg, K, and Na concentrations were not significantly greater in the acidified sections relative to the reference section of the stream. Macroinvertebrate collectors, scrapers, and predators showed a change in drift activity for the first week of acid addition; thereafter, drift behavior was not different for reference and treatment areas. Drift density of species within the shredder functional group was not altered by pH 4.0 stream water.

Hamilton, M. A. 1979. Robust Estimates of the ED50. J. Am. Statist. Assoc. 74(366): 344-354.

To explore the possibility that robust estimators of location can be adapted to the problem of estimating the ED50 in binary-response bioassay, 10 estimators are compared. A Monte Carlo study is conducted to determine the mean squared errors (MSE) of the estimators. Taking into account the MSE for a variety of symmetric tolerance distributions, the sensitivity of the estimator to an anomalous response, and the possibility that the estimator is incalculable, the trimmed Spearman-Karber estimator is especially reliable. Adjusting the response proportions before calculating the ED50 significantly reduces the MSE of the minimum logit chi-squared estimator.

Holcombe, G. W., D. A. Benoit, and E. N. Leonard. 1979. Long-Term Effects of Zinc Exposures on Brook Trout (Salvelinus fontinalis). Trans. Am. Fish. Soc. 108: 76-87. ERL-D Reprint #208.

Exposure of three generations of brook trout (Salvelinus fontinalis) to zinc concentrations ranging from 2.6 to 534 μg/l produced no significant harmful effects. During a separate exposure of embryos and larvae, 1,368 μg Zn/l significantly reduced ($P = 0.05$) both embryo and 12-week larval survival. An additional partial chronic exposure also resulted in significantly reduced ($P = 0.05$) egg chorion strength and embryo survival at 1,360 μg Zn/l. The maximum acceptable toxicant concentration (MATC) for brook trout exposed to zinc in Lake Superior water (hardness = 45.4 mg/l as $CaCO_3$; pH = 7.0-7.7) lies between 534 and 1,360 μg Zn/l. The 96-hr LC50 (median lethal) concentration for brook trout was 2,000 μg Zn/l; thus the application factor (MATC/96-hr LC50) lies between 0.267 and 0.680. Brook trout gill, liver, kidney, and opercular bone tissues accumulated the greatest amounts of zinc. Edible muscle tissue did not accumulate zinc. Zinc loss from gill and liver from first-generation trout transferred to control water for 12 weeks was 55% and 50%, respectively, based on the total micrograms of zinc per whole tissue. Zinc in kidney tissue (based on the total micrograms of zinc per whole tissue) increased 192%, however, during the 12 weeks in control water.

Horning, W. B., and T. W. Neiheisel. 1979. Chronic Effect of Copper on the Bluntnose Minnow, Pimephales notatus (Rafinesque). Arch. Environ. Contam. Toxicol. 8: 545-552. ERL-D Reprint #216.

A laboratory chronic toxicity test in which bluntnose minnows were exposed to copper in laboratory dilution water with a hardness of 200 mg/l as $CaCO_3$ indicated that copper adversely affected fry survival, fry growth, and reproduction. The maximum acceptable toxicant concentration (MATC) for total copper based on reproductive impairment at 18.0 μg/l was between 4.3 (control concentration) and 18.0 μg/l.

The 96-hr LC50 values from three acute toxicity tests ranged from 0.22 to 0.27 mg/l total copper with a mean value of 0.23 mg/l. The application factor (MATC/96-hr LC50) for bluntnose minnows and total copper was estimated to lie between 0.02 and 0.08.

Bluntnose minnows held in control water for nine months ceased to spawn when they were exposed to 119.4 µg/l total copper. Fish exposed to 119.4 µg/l total copper for the same nine-month period began to spawn 60 days after being transferred to control water.

Korfmacher, W. A., D. F. S. Natusch, D. R. Taylor, E. L. Wehry, and G. Mamantov. 1979. Thermal and Photochemical Decomposition of Particulate PAH. IN: Polynuclear Aromatic Hydrocarbons (P. W. Jones, and P. Leber, eds.), pp. 165-170, Ann Arbor Science, Ann Arbor, Michigan.

In order to obtain quantitative data describing the rate and extent of photochemical decomposition of particulate PAH a series of experiments were conducted in which individual PAH were adsorbed onto coal fly ash particles and exposed to both real and simulated sunlight conditions.

The following results have several important ramifications from an environmental standpoint.

1. In general PAH which would normally be expected to undergo photochemical decomposition are stabilized when adsorbed onto coal fly ash. This may result in effective retention of the carcinogenic potential of several compounds (e.g., benzo[a]pyrene).
2. Certain compounds (e.g., those containing benzylic carbon atoms) are rapidly oxidized to the corresponding ketones of quinones as a result of adsorption onto coal fly ash. Whether such oxidation results in a net increase or decrease in the toxic potential of adsorbed PAH is unknown but it does suggest that specific concentrations of particulate PAH in the plume from a coal-fired power plant may differ substantially both between plants and with distance from a given plant stack.
3. Perhaps one of the more interesting ramifications of the nonphotochemical process lies in the fact that certain highly carcinogenic PAH (e.g., dimethylbenzanthracene and 3-methylcholanthrene) contain one or more benzylic carbon atoms and so would be expected to decompose quite rapidly following adsorption onto an active particulate substrate. This process may account for the fact that fluorenone is normally present at much higher levels than fluorene in atmospheric aerosols.

Kreis, R. G., Jr., and E. F. Stoermer. 1979. Diatoms of the Laurentian Great Lakes III. Rare and Poorly Known Species of Achnanthes Bory and Cocconeis Ehr. (Bacillariophyta). J. Great Lakes Res. 5(3-4): 276-291.

New Great Lakes occurrence records of twenty-three taxa of the diatom genus Achnanthes and two of the genus Cocconeis are presented. Seventeen species, five varieties, and one form of Achnanthes as well as one species and one variety of Cocconeis are figured and described. New North American records are noted. Distribution and autecology of these entities in the Great Lakes and other localities are discussed.

Kuechle, V. B., R. A. Reichle, K. E. Zinnel, and M. J. Ross. 1979. Use of a Microprocessor to Locate Fish in Experimental Channels. IN: Proceedings of the Second International Conference on Wildlife Biotelemetry, pp. 33-39, July 30 - August 1, University of Wyoming, Laramie, Wyoming.

An RCA 1802 microprocessor is used to locate fish in a 400 m outdoor experimental channel at the U.S. Environmental Protection Agency Monticello Ecological Research Station. The system consists of horizontally polarized antennas spaced at 30 m intervals. The antennas are sequentially switched into a receiver and the signal strength at each antenna is measured. The microprocessor controls all timing, switching and measurement functions. Each fish in this system is tagged with an rf tag which has a unique frequency in the 53 MHz band. Selecting a particular fish for tracking is equivalent to changing the frequency tuned on the receiver. A microprocessor determines the antenna sending the maximum signal level and prints out this data along with fish number and time of day. A signal to noise margin is calculated by comparing the average signal level to the signal level from the antenna closest to the fish.

Lazinsky, D., and L. Sicko-Goad. 1979. Paraformaldehyde-Glutaraldehyde as a Routine Phytoplankton Fixative. Micron 10: 49-50.

Several fixatives such as Lugol's iodine solution and osmium tetroxide traditionally have been employed in phytoflagellate studies. Lugol's iodine (LI) stains cytoplasmic components, making the algae easier to study with a light microscope while at the same time it preserves their flagella. However, this fixative is not suitable for electron microscopy.

We have been utilizing paraformaldehyde-glutaraldehyde (PFG) for fixing natural phytoplankton assemblages and find that the flagella of some of the more common genera such as Cryptomonas, Chroomonas, and Rhodomonas are intact, making the flagellate component of the assemblage easier to identify and study.

Lemke, A. E., and W. F. Dawson. 1979. Temperature-Monitoring and Safety-Control Device. Prog. Fish-Cult. 41(3): 165-166. ERL-D Reprint #214.

A two channel (sensitive) temperature monitor is described, and a parts list and wiring diagram are given. This equipment can be used as a safety shut-off or alarm system, or both. The sensitivity is 0.3°C.

Magnuson, V. R., D. K. Harriss, M. S. Sun, D. K. Taylor, and G. E. Glass. 1979. Relationships of Activities of Metal-Ligand Species to Aquatic Toxicity. IN: Chemical Modeling in Aqueous Systems (E. A. Jenne, ed.), pp. 635-656, American Chemical Society Symposium Series No. 93. ERL-D Reprint #209.

Water quality criteria for toxicity of metal-ligand species to aquatic life are investigated by computer modeling. The speciation calculations are performed using REDEQL2. Correlations of toxicity to concentrations (or activities) or particular species or types of species are discussed with respect to three laboratory studies on zinc and copper.

McCall, P. L., M. J. S. Tevesz, and S. F. Schwelgien. 1979. Sediment Mixing by _Lampsilus radiata siliquoidea_ (Mollusca) from Western Lake Erie. J. Great Lakes Res. 5(2): 105-111.

The sediment reworking activities of an abundant Lake Erie unionid bivalve, _Lampsilis radiata siliquoidea_, have been studied by field observations and laboratory experiments. Unionid burrowing in laboratory microcosms increased sediment water content 10-20%, decreased water content variability, homogenized sedimentary structures, and increased tenfold the volume of oxidized sediment over that in microcosms with no unionids. Incomplete mixing of sediment took place to a depth of 10 cm during burrowing by _L. r. siliquoidea_. Burrowing by other unionids may extend the depth of maximum reworking to 20 cm. Unionid burrowing, feeding, and respiratory activities may alter the profiles of various elements and radionuclides associated with sediment particles and alter the location and intensity of microbial activity in sediments.

McNaught, D. C. 1979. Considerations of Scale in Modeling Large Aquatic Ecosystems. IN: Perspectives on Lake Ecosystem Modeling, Chapter 1 (D. Scavia, and A. Robertson, eds.), pp. 3-24, Ann Arbor Science, Ann Arbor, Michigan.

Modelers are often provided with mean estimates of biomass for a particular season and, in unusual cases, with estimates of fluxes. Since most uptake processes are characterized by high nonlinearity between process rate and resource concentration, it is critical that modelers have estimates of variability for such processes available, accompanied by the results of behavioral-physiological studies that indicate whether organisms such as zooplankton are able to locate aggregations of phytoplankton, thus feeding at very high cell concentrations, or whether they feed at resource concentrations approximating the environmental mean concentration.

Specific objectives of this synthesis include: (a) the description of the spatial-temporal scales of phytoplankton, zooplankton and fish distributions in large lakes, including extremes in the patchiness of both biomass and those rate functions such as grazing and excretion that lead directly to further patchiness of phytoplankton and nutrients; (b) the discovery of spatial-temporal interactions that underlie increased efficiencies of ecosystem functioning; (c) the search for evidence of coincidence of spatial-temporal scales of predator-prey species necessary to such increased efficiency; and (d) the application of information on heterogeneity in distributions of planktonic biomass and associated fluxes to model calibration.

Four basic processes characteristic of open-water, planktonic systems are considered: nutrient cycling, primary production and secondary production (herbivory and carnivory). Variations in fluxes characteristic of these processes, as well as the magnitude of important rapidly cycling biomasses, are described.

Melancon, M. J. 1979. Metabolism of Phthalate Esters in Aquatic Species. IN: Pesticide and Xenobiotic Metabolism in Aquatic Organisms (M. A. Q. Kahn et al., eds.), pp. 77-94, American Chemical Society Symposium Series No. 99.

Concern over the fate of phthalate esters in the aquatic environment has resulted in studies of the fate of phthalate esters in a number of aquatic species. Among the aquatic organisms which have been shown to metabolize phthalate esters, are microorganisms present in water, hydrosoil and sewage sludge, several invertebrates and several fish species.

Melancon, M. J., Jr., and J. J. Lech. 1979. Structural Requirements for the Inhibition of Phthalate Ester Hydrolysis in Rainbow Trout by Methylenedioxyphenyl Compounds. Xenobiotica 9(5): 317-322.

1. The ability of a number of methylenedioxyphenyl compounds and paraoxon to inhibit the hydrolysis and oxidation of di-2-ethylhexyl phthalate by rainbow trout tissue preparations was examined.

2. In addition to paraoxon, only the methylenedioxyphenyl compounds with long side-chains (piperonyl butoxide and tropital) inhibited the hydrolysis of di-2-ethylhexyl phthalate by trout liver subcellular fractions and trout serum.

3. Paraoxon decreased the production of the major metabolite of di-2-ethylhexyl phthalate by trout liver microsomes (+NADPH) suggesting that this metabolite arises via further metabolism and mono-2-ethylhexyl phthalate.

Melancon, M. J., Jr., and J. J. Lech. 1979. Uptake, Biotransformation, Disposition, and Elimination of 2-Methylnaphthalene and Naphthalene in Several Fish Species. IN: Aquatic Toxicology, ASTM STP 667 (L. L. Marking, and R. A. Kimerle, eds.), pp. 5-22, American Society for Testing and Materials.

The uptake, disposition, biotransformation, and elimination of ^{14}C-2-methylnaphthalene and ^{14}C-naphthalene have been studied in several species of fish. The half-lives of elimination of ^{14}C from several tissues, following the exposure of rainbow trout fingerlings to both compounds for 8 h, were less than 24 h. After exposure of the trout to ^{14}C-naphthalene for four weeks, the half-life of elimination was hundreds of hours. After exposure to ^{14}C-2-methylnaphthalene for four weeks, the elimination of ^{14}C was biphasic; the rapid phase of elimination had a half-life of less than 24 h while the half-life of the slow phase was hundreds of hours. Examination of the muscle ^{14}C by thin-layer chromatography (TLC) suggested that differential elimination of the parent compound and its metabolites may be involved in these differences. The elimination of ^{14}C from fingerling carp after four weeks of exposure to ^{14}C-2-methylnaphthalene, was also biphasic.

Bile ^{14}C from rainbow trout, carp, and sheepshead which had been exposed to ^{14}C-2-methylnaphthalene was present mainly as metabolites. Most of the metabolites appeared to be conjugated when examined by TLC.

Greater bile ^{14}C to water ^{14}C ratios resulted from exposure of the fish to ^{14}C-2-methylnaphthalene than from exposure to ^{14}C-naphthalene and were probably related to the greater uptake of ^{14}C-2methylnaphthalene. This ratio was also affected by the water level of the chemical, the exposure duration, and the species of the fish.

The disposition and biotransformation of ^{14}C-naphthalene, ^{14}C-2-methylnaphthalene, and ^{14}C-1,2,4-trichlorobenzene in rainbow trout were affected by pretreatment of the trout with an inducer of microsomal enzymes, β-naphthoflavone. Bilary ^{14}C levels were much higher in the induced trout, and the tissues contained a greater proportion of ^{14}C as metabolites in the induced trout than in the controls.

Miguel, A. H., W. A. Korfmacher, E. L. Wehry, G. Mamantov, and D. F. S. Natusch. 1979. Apparatus for Vapor-Phase Adsorption of Polycyclic Organic Matter onto Particulate Surfaces. Environ. Sci. Technol. 13(10): 1229-1232.

The design and operation of an apparatus for vapor-phase adsorption of polycyclic organic matter (POM) onto the surface of coal fly ash and other solid adsorbents are described. Provision is made for vapor-phase fluorometric analysis of the effluent vapor stream in the adsorption apparatus. Several POMs were adsorbed, at fixed temperatures, on the surface of fly ashes collected with electrostatic precipitators of coal-fired power plants. The adsorption of vapor-phase pyrene in the temperature range of 150-265°C revealed that the adsorption equilibrium capacity of the fly ashes and the equilibration time both decreased linearly with increasing temperature. The results of these measurements indicate that the amount of adsorbed POM can be controlled quite easily by adjusting either the time or temperature of adsorption.

Mount, D. I. 1979. Adequacy of Laboratory Data for Protecting Aquatic Communities. IN: Analyzing the Hazard Evaluation Process (R. L. Dickson et al., eds.), pp. 112-118, Water Quality Section, Am. Fish. Soc., Washington, D.C.

When the protection of aquatic communities is discussed relative to water-pollution control efforts, we must recognize that adequacy of protection may be judged on a different basis by the public and by the ecologist: by the former on community features; by the latter on community functions. Public attitudes are important, however, because public support is crucial to the funding of both research and regulation. Community functions are often not perceived by the public as important.

Olson, G. J., S. C. Turbak, and G. A. McFeters. 1979. Impact of Western Coal Mining - II. Microbiological Studies. Water Res. 13: 1033-1041.

The occurrence and activity of certain groups of sulfur cycle bacteria associated with waters, sediments, and coal bearing strata of a coal strip mine at Decker, Montana, were studied. Mining areas in northeastern Wyoming were also examined.

Thiobacillus ferrooxidans, one of the major contributors to acid mine drainage, was consistently detected in the mining environment. Physiological studies of *T. ferrooxidans* isolates indicated that these acidophilic iron and sulfur oxidizing orgnisms were typical of the species in their preference for low pH and ability to oxidize pyrite.

Since (i) acidic conditions were not observed at Decker, (ii) the organisms did not multiply in mine water environments, and (III) no acid could be formed from coal samples inoculated with a *T. ferrooxidans* isolate, it was thought that their activity was limited to microzones in the coal bearing strata where they oxidized sulfuritic material. Any acid formed was quickly neutralized by mineral carbonates associated with the groundwaters and overburden.

Sulfate reducing bacteria also were common in the mine waters and sediments. These organisms were particularly active in the sedimentation pond sediments as was evidenced by the rapid rate of conversion of radio-labeled sulfate to sulfide. The hydrogen sulfide produced by these organisms contributed to heavy metal precipitation in the sedimentation pond.

Oseid, D. M., and L. L. Smith, Jr. 1979. The Effects of Hydrogen Cyanide on *Asellus communis* and *Gammarus pseudolimnaeus* and Changes in Their Competitive Response when Exposed Simultaneously. Bull. Environ. Contam. Toxicol. 21: 439-447.

Most studies of the long-term effects of toxicants have exposed a single species in each chamber. This study was designed to determine the effect of the presence of a second organism on the reaction of a test animal to cyanide. The first organism *Gammarus pseudolimnaeus* Bousfield was chosen because of its aggressive and competitive behavior and the second, *Asellus communis* Say, because it has a passive nature. *Asellus communis* has also been shown in previous short-term tests to be much more resistant to hydrogen sulfide than *Gammarus*, and it was thought that a similar reaction would result with exposure to hydrogen cyanide. In the present study, short-term tests were done on each species alone and then full-life-cycle tests were done on each species alone and then with the two together.

Pfeifer, K. F., and L. J. Weber. 1979. The Effect of Carbon Tetrachloride on the Total Plasma Protein Concentration of Rainbow Trout, *Salmo gairdneri*. Comp. Biochem. Physiol. 64C: 37-42.

1. The effect of a single i.p. injection of CCl_4 on total plasma protein and albumin concentrations was measured in the rainbow trout.

2. CCl_4 treatment caused a significant reduction in total plasma protein concentration at 12, 24 and 36 hr post-treatment.

3. At 24 hr post-treatment plasma albumin concentration was significantly reduced only in fish given the highest dose of CCl_4 (2.0 ml/kg).

4. Several factors, including intestinal inflammation and hemorrhages, could have contributed to the decreased plasma protein concentration in the trout.

Poldoski, J. E. 1979. Cadmium Bioaccumulation Assays. Their Relationship to Various Ionic Equilibria in Lake Superior Water. Environ. Sci. Technol. 13(6): 701-716. ERL-D Reprint #210.

> The potential use of bioaccumulation by Daphnia magna as an analytical tool in studying properties of various aqueous cadmium forms is described. Selected aquatic chemical factors affecting cadmium residues were determined for organisms exposed to cadmium in the absence and presence of various organic and inorganic chemicals, some capable of strongly complexing cadmium. Without any added complexing agents, steady-state relationships were observed between total aqueous cadmium concentrations (2×10^{-10}-9×10^{-8} M) and bioaccumulated cadmium (0.09-3.2 μg/g, wet weight) within 2-4 days of exposure. Residues were a nonlinear function of the concentration. The presence of humic acid, pyrophosphate, or aminopolycarboxylic acids, at sufficient concentrations to maximize complexation, was effective, to various degrees, in reducing cadmium uptake. However, cadmium in the presence of diethyldithiocarbamate bioaccumulated to a greater degree than in its absence.

Riedel, B., and G. Christensen. 1979. Effect of Selected Water Toxicants and Other Chemicals Upon Adenosine Triphosphate Activity In Vitro. Bull. Environ. Contam. Toxicol. 23: 365-368. ERL-D Reprint #213.

> Nineteen selected water pollutants of different chemical classes were tested for inhibitory effect (in vitro) on the enzyme, adenosinetriphosphatase. The salts of silver, mercury, copper and cadmium were most inhibiting, followed by the chlorinated hydrocarbon pesticide, dicofol. The pesticides, DDT, dieldrin, lindane, carbaryl and malathion were also inhibiting but to a lesser degree, as was methyl mercury, aluminum, fluoride, nickel and cobalt ions. Sulfide ion and sodium chloride at 10^{-2}M caused no change in enzyme activity.

Robbins, J. A., P. L. McCall, J. B. Fisher, and J. R. Krezoski. 1979. Effect of Deposit Feeders on Migration of ^{137}Cs in Lake Sediments. Earth Planet. Sci. Lett. 42: 277-287.

> Illite clay particles with adsorbed ^{137}Cs were added as a submillimeter layer to the surface of silt-clay sediments contained in rectangular Plexiglas cells stored in a temperature-regulated aquarium, in order to trace the effect of the oligochaete, Tubifex tubifex, and the amphipod, Pontoporeia hoyi, on mass redistribution near the sediment-water interface. A well-collimated NaI gamma detector scanned each sediment column (~10 cm deep) at daily or weekly intervals for six months, depicting the time evolution of radioactivity with and without added benthos. In a cell with tubificids (~5×10^4 m^{-2}), which feed below 3 cm and defecate on surface sediments, the labeled layer was buried at a rate of 0.052 ± 0.007 cm/day (20°C). When labeled particles entered the feeding zone, ^{137}Cs reappeared in surface sediments

creating a bimodal activity profile. In time, the activity tended toward a uniform distribution over the upper 6 cm, decreasing exponentially below to undetectable levels by 9 cm. In a cell with amphipods (~1.6 x 10^4 m^{-2}) uniform activity developed rapidly (~17 days) down to a well-defined depth (1.5 cm). The mixing of sediments by Pontoporeia is described by a simple quantitative model of eddy diffusive mixing of sediment solids. The value of the diffusion coefficient, 4.4 cm^2/yr (7°C) was computed from a least squares fit of theoretical to observed profile broadening over time. In a cell without benthos, small but measurable migration of ^{137}Cs indicated an effective molecular diffusion coefficient of 0.02 cm^2/yr.

Ross, M. J., V. B. Kuechle, R. A. Reichle, and D. B. Siniff. 1979. Automatic Radio Telemetry Recording of Fish Temperature and Depth. IN: Proceedings of the Second International Conference on Wildlife Biotelemetry, pp. 238-247, July 30 - August 1, University of Wyoming, Laramie, Wyoming.

Radio frequency fish transmitters capable of relaying temperature or pressure information and a multichannel recording system have been developed and used successfully in the field. Both transmitters operated on pulse rate variation with either temperature or depth. Design considerations for temperature and pressure dependent pulse rates are discussed, including power supply variation, sensitivity ranges, drift, size, power consumption and temperature variation. The receiving-recording system is described, including a 16 channel programable scanning receiver and pulse decoder.

Sheng, Y. P., and W. Lick. 1979. The Transport and Resuspension of Sediments in a Shallow Lake. J. Geophys. Res. 84(C4): 1809-1826.

The time-dependent flow and dispersion of suspended sediments in the western basin of Lake Erie are being studied by means of numerical models utilizing data from remote-sensing studies and flume experiments. Mechanisms of sediment dispersion included in the models are convection and turbulent diffusion, river loading, gravitational settling, and physical resuspension and deposition at the sediment-water interface. The time-dependent currents are computed by means of a free surface hydrodynamic model. A wave-hindcasting model is used to compute the wave parameters needed for estimation of shear stress generated at the sediment-water interface under given wind conditions. The rate of sediment resuspension as a function of bottom shear stress and sediment properties is based on data from flume experiments using lake sediments. A series of numerical calculations with the models were performed on a two-dimensional lake with a variable bottom representing a transverse cross section of Lake Erie. It was found that wind direction and fetch length can significantly affect the sediment dispersion patterns. The two-dimensional and the three-dimensional models were both used to simulate realistic short-term events in Lake Erie, and the model outputs compare favorably with the synoptic surface sediment dispersion patterns deduced from the multispectral scanner data.

Sicko-Goad, L., and E. F. Stoermer. 1979. A Morphometric Study of Lead and Copper Effects on *Diatoma tenue* var. *elongatum* (Bacillariophyta). J. Phycol. 15: 316-321.

> Polyphosphate bodies containing lead were induced in laboratory cultures of *Diatoma tenue* var. *elongatum* Lyngb. by the addition of phosphorus and 0.05 μg-atoms/l Pb to P deficient medium. Morphometric analysis of cells exposed to Pb showed a significant decrease in number of mitochondria with a concomitant increase in their volume and an increase in membranous organelles in the vacuole compared to phosphorus starved and phosphorus sufficient controls. Exposure of cultures to 0.08 μg-atoms/l copper resulted in reduction of the number of polyphosphate bodies formed during luxury uptake but no other significant morphological changes in cellular organelles. Ecological implications of the interactions between nutrients and low level trace metal contamination are discussed.

Sicko-Goad, L., and G. Walker. 1979. Viroplasm and Large Virus-Like Particles in the Dinoflagellate *Gymnodinium uberrimum*. Protoplasma 99: 203-210.

> Virus-like particles (VLPs) measuring 385 ± 5 nm diameter are described in the freshwater dinoflagellate *Gymnodinium uberrimum*. The VLPs are found in association with, and "budding" from a vesicular viroplasmic area. A similar viroplasm was also found in a chrysophycean alga, *Mallomonas* sp. collected from the same general area in Saginaw Bay of Lake Huron. The nature of these VLPs and their virogenic stroma, in these algae from the Laurentian Great Lakes are discussed in the present report.

Spehar, R. L., G. W. Holcombe, R. W. Carlson, R. A. Drummond, J. D. Yount, and Q. H. Pickering. 1979. Effects of Pollution on Freshwater Fish. J. Water Pollut. Control Fed. 51(6): 1616-1694. ERL-D Reprint #212.

> An extensive review of 478 references on the effects of pollution on freshwater fish for 1977-1978 is presented. These references cover: Reviews and Symposia, Dissolved Gases, pH, Insecticides, Herbicides, Piscicides and Anesthetics, Inorganics and Organic Chemicals, Chlorine and Sewage, Pulp and Paper, Radioactivity and Physical Factors.

Spehar, R. L., G. D. Veith, D. L. DeFoe, and B. V. Bergstedt. 1979. Toxicity and Bioaccumulation of Hexachlorocyclopentadiene, Hexachloronorbornadiene and Heptachloronorbornene in Larval and Early Juvenile Fathead Minnows, *Pimephales promelas*. Bull. Environ. Contam. Toxicol. 21: 576-583. ERL-D Reprint #207.

The toxicity and bioaccumulation studies of hexachlorocyclopentadiene, hexachloronorbornadiene and heptachloronorbornene to fathead minnow larvae and early juveniles were conducted for 30 days under flow through conditions. The 96-hr LC50 and 30-day LC50 values for these compounds, respectively were: 7.0 and 6.7 μg/l, 188 and 123 μg/l, and 85.6 and 60.1 μg/l. Residues of hexachlorocyclopentadiene in 30-day-old larvae were less than 0.1 μg/l resulting in a BCF of <11. The concentration of hexachloronorbornadiene and heptachloronorbornene accumulated by fathead minnows was directly proportional to the mean exposure concentration up to an effect concentration of approximately 40 μg/l and resulted in BCFs of 6,400 and 11,200 for each compound, respectively.

Stoermer, E. F., J. C. Kingston, and L. Sicko-Goad. 1979. The Morphology and Taxonomic Relationships of *Stephanodiscus binderanus* var. *oestrupii*. Nova Hedwigia Beiheft 64: 65-78.

Populations of *Stephanodiscus binderanus* var. *oestrupii* from the Laurentian Great Lakes of North America regularly produce paired valves with grossly different morphology than the majority of cells in a given colony. Modifications include thickening of the valve, reduction in number and partial or total occlusion of the punctae, and simplification of the branched submarginal spines. In obligately colonial *S. binderanus* var. *oestrupii* the modified valves apparently function as "separation valves" allowing reduction in colony size without mechanical disruption of the cells. Similarly modified valves are also occasionally noted in populations of *S. tenuis* Hust. from the same habitat although this species may occur either singly or in small colonies. Growth habit of this species is determined by modification of spine structure.

Sydor, M., J. A. Sorensen, and V. Shuter. 1979. Remote Sensing of Snow Albedo for Determination of Dustfall. Applied Optics 18(21): 3574-3578.

Changes in snow reflectivity as a function of dustfall were used to measure dust deposition rates in terms of satellite reflectivity data. The results show that for dry snow conditions, snow reflectivity can be approximated by Kubelka-Munk theory. Dustfall above threshold values of 10 $\mu g/cm^2$ can be detected using Landsat computer tape data. Determination of dust deposition over ice-covered lakes and harbors appears in good agreement with sampling measurements.

Thomann, R. V. 1979. An Analysis of PCB in Lake Ontario Using a Size-Dependent Food Chain Model. IN: Perspectives on Lake Ecosystem Modeling, Chapter 12 (D. Scavia, and A. Robertson, eds.), pp. 293-320, Ann Arbor Science, Ann Arbor, Michigan.

In this paper, a generalized model is presented that is focused specifically on the aquatic ecosystem and the transport and accumulation of hazardous substances in the aquatic food chain. The PCB problem in Lake Ontario is used as the problem setting. Specific toxicological effects are not included in this work; the emphasis is on the fate of the substance in the aquatic ecosystem. The model is presented as an example of a framework in an early developmental stage in contrast to the more complex models of phytoplankton biomass dynamics. Consequently, the thrust of the model is on simplified analytical structures requiring only simple computations.

Turbak, S. C., G. J. Olson, and G. A. McFeters. 1979. Impact of Western Coal Mining - I. Chemical Investigations of a Surface Coal Mine Sedimentation Pond. Water Res. 13: 1023-1031.

Chemical investigations of the sedimentation pond system at the West Decker Mine in southeastern Montana, U.S.A., were undertaken during an 18 month period from November 1975 to April 1977. Sedimentation pond water, essentially "altered" groundwater, differed chemically from the average groundwater in coal-bearing aquifers. The increase in certain chemical constituents (sodium, sulfate, bicarbonate and inorganic nitrogen) and the decrease in dissolved oxygen in pond water during autumn 1976 and winter 1977 was the result of erratic pond operation, dredging, and increased nearby mining activity. Discharge from the pond complied with the guidelines advanced for effluents from surface coal mines. Levels of mercury in water samples collected from the sedimentation pond system were higher than those recommended for the protection of aquatic life and wildlife. The suitability of pond water for selected purposes and recommendations for improvement in pond design are discussed.

Veith, G. D., N. M. Austin, and R. T. Morris. 1979. A Rapid Method for Estimating Log P for Organic Chemicals. Water Res. 13: 43-47. ERL-D Reprint #201.

The logarithm of the retention time (log RT) of organic chemicals on a permanently bonded (C-18) reverse-phase high-pressure liquid chromatography system is shown to be linearly related to the logarithm of the n-octanol/water partition coefficient (log P). A rapid, inexpensive technique based on reverse-phase high-pressure liquid chromatography has been developed to estimate the n-octanol/water partition coefficient of organic chemicals. The system consists of a preparative Micro-Pak® C-10 reverse-phase column eluted with a 15% water/85% methanol solvent flowing at 2 ml min^{-1} at room temperature.

A linear calibration of the logarithm of retention time with the logarithm of the partition coefficient (log P) is attained by using a mixture of benzene, bromobenzene, biphenyl, bibenzyl, p,p'DDE, and

2,4,5,2',5'-pentachlorobiphenyl as reference standards of known log P. Using a calibration mixture, the log P of other organic chemicals were estimated with a mean accuracy of 22.8% of the log P values reported in the literature. The technique permits estimation of log P in a maximum of 25 min and does not require a knowledge of the structure of the chemical for the estimate.

Veith, G. D., D. L. DeFoe, and B. V. Bergstedt. 1979. Measuring and Estimating the Bioconcentration Factor of Chemicals in Fish. J. Fish. Res. Board Can. 36: 1040-1048. ERL-D Reprint #215.

A method of estimating the bioconcentration factor of organic chemicals in fathead minnows (Pimephales promelas) is described. Water at 25°C was intermittently dosed with the chemical at a nontoxic concentration in a flow-through aquarium. Thirty minnows are placed in the aquarium, and composite samples of five fish are removed for analysis after 2, 4, 8, 16, 24, and 32 d of exposure. The bioconcentration process is summarized by using the first-order uptake model, and the steady-state bioconcentration factor is calculated from the 32-d exposure. A structure-activity correlation between the bioconcentration factor (BCF) and the n-octanol/water partition coefficient (P) of individual chemicals is summarized by the equation log BCF = 0.85 log P - 0.70, which permits the estimation of the bioconcentration factor of chemicals to within 60% before laboratory testing. The facilities and resources for testing need be used only for those chemicals that are likely to result in substantial bioconcentration in organisms. The bioconcentration factors derived from tests of mixtures of chemicals are shown to be the same as those derived from tests with the chemicals individually.

Veith, G. D., D. W. Kuehl, E. N. Leonard, F. A. Puglisi, and A. E. Lemke. 1979. Polychlorinated Biphenyls and Other Organic Chemical Residues in Fish from Major Watersheds of the United States, 1976. Pestic. Monit. J. 13(1): 1-11. ERL-D Reprint #211.

Composite samples of fish were collected from major United States watersheds in 1976 and analyzed for PCBs and related organic chemicals. PCBs were found in 93 percent of the fish samples; 53 percent of the samples contained more than 5 ppm PCBs, whole fish basis, which is the current tolerance level set by the Food and Drug Administration, U.S. Department of Health, Education and Welfare. Only 14 percent of the samples contained less than the proposed action level of 2 ppm PCBs. PCB concentrations ranged from less than 0.3 ppm to 140 ppm in the composite samples. DDT concentrations ranged from less than 0.05 ppm to 4.53 ppm. Hexachlorobenzene was identified in 19 percent of the samples, and chlordane components were identified in 36 percent of the samples. Chemicals identified by gas chromatography/mass spectrometry but not quantified include chlorinated benzenes, styrenes, anisoles, phenols, anilines, propanes, and butadienes, as well as mixtures of petroleum hydrocarbons.

Walker, G. K., L. Sicko-Goad, and E. F. Stoermer. 1979. An Ultrastructural Examination of the Pennate Diatom Caloneis amphisbaena. Microbios Lett. 12: 141-152.

> This study details a scanning and transmission electron microscopic analysis of Caloneis amphisbaena. Each valve chamber of Caloneis is occupied by a single mitochondrion or mitochondrial lobe, and mitochondria are also found encircling large, cytoplasmic, membrane-bound fibrillar bundles. The possible sources of function of these fibrils is discussed. In addition, considerable attention is given to extensions of the pre-divisional nuclear envelope which project into the cytoplasm. Each membranous "flap" appears closely associated with a pair of golgi bodies.

Waller, W. T., and G. F. Lee. 1979. Evaluation of Observations of Hazardous Chemicals in Lake Ontario During the International Field Year for the Great Lakes. Environ. Sci. Technol. 13(1): 79-85.

> Data collected during the International Field Year for the Great Lakes (IFYGL) studies on Lake Ontario are summarized relative to their recommended International Joint Commission (IJC) Water Quality Objective Subcommittee water quality objectives or U.S. Environmental Protection Agency Quality Criteria for Water, of July 1976. Data from 247 stations were used to summarize information on the following parameters: cadmium, zinc, chromium, copper, fluoride, iron, lead, nickel, manganese, and ammonia. Chlorinated hydrocarbon data for DDT, dieldrin, and PCBs are discussed relative to concentrations determined in water samples and three fish species. Summaries indicate that almost all reported measurements for total cadmium, regardless of the region of the lake from which the samples were collected (i.e., open water, shoreline, or river mouth), exceed the IJC water quality objective of 0.2 μg/l by at least five times. Values reported for copper also showed a high percentage of measurements from all regions of the lake equal to or in excess of the recommended IJC water quality objective. Other metals showed more regional patterns of values equalling or exceeding water quality objectives. The concentrations of PCBs, dieldrin, and DDT and its metabolites in Lake Ontario water and fish were found to exceed the IJC water quality objectives and the U.S. EPA water quality criteria.

Weber, L. J., W. H. Gingerich, and K. F. Pfeifer. 1979. Alterations in Rainbow Trout Liver Function and Body Fluids Following Treatment with Carbon Tetrachloride or Monochlorobenzene. IN: Pesticide and Xenobiotic Metabolism in Aquatic Organisms (M. A. Q. Kahn et al., eds.), pp. 401-413, ACS Symposium Series, No. 99, American Chemical Society.

> The use of clinical diagnostic procedures to identify and evaluate specific organ dysfunction is used widely in human and mammalian toxicology. Despite the apparent usefulness of such techniques little

has been done to develop similar methods for use in studying toxic responses in aquatic organisms. Recently we have evaluated several exogenous and endogenous tests of liver function in rainbow trout following intoxication by the model hepatotoxicant, CCl_4. The results of these studies indicate that elevated plasma activity of the enzyme glutamate-pyruvate transaminase (GPT) is the most sensitive endogenous index of liver damage in trout of the several enzyme systems tested. Similarly, we have presented data indicating that liver function studies based on plasma clearance of the organic anion sulfobromophthalein (BSP) also are useful in evaluating liver damage in rainbow trout. The intent of the present study was to compare and contrast two model mammalian hepatotoxic agents for their potential to produce hepatotoxicity in the rainbow trout.

The results indicate that use of simple clinical diagnostic tests to screen for liver dysfunction appears to be practical in trout. However a test of organ function used in combination with enzyme tests and histological screening appear to be most useful in the overall assessment of organ dysfunction provided that the limitations of each test are recognized.

Whitworth, C., and G. K. Pagenkopf. 1979. Cadmium Complexation by Coal Humic Acid. J. Inorg. Nucl. Chem. 41: 317-321.

Humic acid (HA) has been extracted with base from a sub-bituminous coal and characterized. Complexation studies with cadmium indicate the formation of complexes with stoichiometry; CdHA, Cd_2HA and Cd_3HA. The log β^*_{11} values for CdHA at pH 5.5, 6.0, 7.0 and 7.5 are 4.9, 5.3, 5.9 and 6.3, respectively. For Cd_2HA at pH 6.0, 7.0 and 7.5 the log β^*_{22} values are 9.2, 10.6 and 11.7 and at pH 6.0, 7.0 and 7.5 the log β^*_{31} values are 13.7, 15.7 and 16.5, respectively. The average gram formula weight is 6761 ± 842.

EPA RESEARCH REPORTS

Biesinger, K. E., R. P. Brown, C. R. Bernick, G. A. Flittner, and K. E. F. Hokanson. 1979. A National Compendium of Freshwater Fish and Water Temperature Data. Volume I. Data Management Techniques, Output Examples and Limitations. U.S. Environmental Protection Agency, Duluth, Minnesota. Publication No. EPA-600/3-79-056. 208 pp.

The present study resulted in the compilation of a computer data base containing historical fish distribution data with accompanying water temperature data from about 1930-1972 for over 300 species of freshwater fish from 574 locations in the United States and provides the first nationwide compendium that describes freshwater fish population habitats in relation to water temperature regimes. Data collected from many unrelated sources were edited, formatted and assembled into a meaningful presentation. The transformation of the encoded data into magnetic characters on a computer data tape was accomplished with a Honeywell 702 Keytape machine. Computer programs developed were written in the FORTRAN IV language and implemented on the Univac 1108 computer system. The present data system was implemented primarily as a computer data storage and retrieval method. As such, the computer programs were largely designed to format, sort, store and recall selected records, or groupings of data.

For analyzing data, computer programs were developed for: (1) determining the frequency of occurrence of certain types and classes of data; (2) determining the number of fish temperature data sets (fish present at the same time and place water temperatures were taken) by: a) major and minor river basins, b) thermal characteristics, c) sampling method, and d) temperature and fish catching equipment type; (3) compiling fish species data and correlating these with water temperature records; (4) producing tables with minimum, maximum and mean temperatures with corresponding fish counts; and (5) producing cumulative percentiles of weekly water temperatures for each fish species. Suggestions as to possible uses for the data and programs are given. Also included are some case example studies.

A section is included describing the limitations of the encoded fish and temperature data and a critique of the: (1) data quality, (2) environmental quality, (3) quality of the work performed, (4) materials and methods used to collect fish and temperature data, and (5) data reporting and analysis.

Canton, S. P., and J. V. Ward. 1979. Environmental Effects of Western Coal Surface Mining. Part I - The Limnology and Biota of Mine Spoils Ponds in Northwest Colorado. U.S. Environmental Protection Agency, Duluth, Minnesota, Publication No. EPA-600/3-79-124. 39 pp.

Physico-chemical conditions, zooplankton, and benthos were investigated from June 1977 to May 1978 in coal strip-mine ponds in northwestern Colorado. Two spoils ponds received all of their drainage from the coal mine, but differed in age; one pond received partial drainage from the mine spoils; a control pond was located in an adjacent drainage basin. There were no discernible effects of mine drainage on a variety of physico-chemical parameters, such as temperature, dissolved oxygen, and hardness. In stark contrast to spoils ponds in the eastern and midwestern states, acid mine drainage was not observed. The pH was near or greater than neutrality and acidity was not detected in the ponds studied. Total dissolved solids, nitrate and sulfate values were higher in the spoils ponds than in the control pond. Net zooplankton abundance was lowest in the youngest spoils pond, but the standing crop of benthos exhibited a progressive decrease from the youngest spoils pond to the control pond. Zooplankton and benthos species diversity were lower in the spoils ponds. Certain groups of zooplankters (Cladocera) and benthos (caddisflies, amphipods, water mites, and fingernail clams) were rare or abent in the youngest spoils pond. Colonization phenomena (age and distance from a source of colonizers) are postulated as responsible, in part, for the faunal differences between ponds, although higher levels of nitrate, sulfate, and TDS in the spoils ponds may provide adverse conditions for certain species. If these data are typical of the western energy region, they suggest the potential for development of recreational lakes as part of reclamation practices.

Carlson, R. M., A. R. Oyler, E. H. Gerhart, R. Caple, K. J. Welch, H. L. Kopperman, D. Bodenner, and D. Swanson. 1979. Implications to the Aquatic Environment of Polynuclear Aromatic Hydrocarbons Liberated from Northern Great Plains Coal. U.S. Environmental Protection Agency, Duluth, Minnesota, Publication No. EPA-600/3-79-093. 156 pp.

The effects of leaching processes upon Western Great Plains coal were investigated to ascertain the potential impact of the organic components on aquatic organisms. Acute and chronic toxicity testing indicated no critically adverse effects, which led to a subsequent detailed study on the lipophilic fraction containing polynuclear aromatic hydrocarbons (PAH) that might be anticipated to bioaccumulate. HPLC-GC analysis of coal leachate indicated that the PAH content was of a comparable concentration to samples obtained from Lake Superior. GC-MS analysis of the lipophilic materials that are adsorbed on the coal particulates indicated that they were predominantly low molecular weight PAH's (i.e. naphthalenes, phenanthrenes, anthracenes, etc.), alkanes, and heterocycles. Synthetic methodology was developed to provide standard samples of alkylated PAH's of the type observed during the MS analysis.

The biological studies on PAH's were aided by the use of a combined HPLC-GC analysis procedure (ng/l detection level) developed specifically for this program. The biological investigation resulted in obtaining bioaccumulation factors in the range of 1000-5000 for several PAH's and noting that the PAH's that induced mixed-function oxidase (MFO) activity in rainbow trout were those that showed similar effects in mammalian systems.

Selected PAH's of various structural types were also shown to be quite susceptible to chemical transformations during conditions typical to chlorine disinfection. The chlorination products that were observed during the course of this investigation were mixtures of chloro- and oxygenated derivatives.

Crook, L. T., and W. C. Sonzogni. 1979. Great Lakes Environmental Planning Using Limnological Systems Analysis: Summary. U.S. Environmental Protection Duluth, Minnesota, Publication No. EPA-600/3-79-011a. 30 pp.

The report documents the deliberate decision making process used by the Great Lakes Basin Commission in concluding that rational modeling methodologies could be used to evaluate the effect of different planning alternatives on the Great Lakes and that planning for specific problems affecting the Great Lakes system can be technically and economically supported through mathematical modeling and systems analysis. It assesses the technical and economical feasibility of developing mathematical models to assist in making selections from among alternative management strategies and structural solutions proposed for solving water resource problems of the Great Lakes. The study reviews, evaluates and categorized present and future water resources problems, presently available data, problem-oriented mathematical models and the state of models and model synthesis for large lakes. A demonstration modeling framework for planning is developed and applied to western Lake Erie and the Great Lakes system. The report evaluates four widely ranging alternatives for future modeling efforts in the Great Lakes and recommends the modeling level most feasible to answer planning questions on scales ranging from the Great Lakes to regional areas. Also discussed is a proposed Commission study which will apply limnological systems analysis to the planning process.

Gingerich, W. H., and L. J. Weber. 1979. Assessment of Clinical Procedures to Evaluate Liver Intoxication in Fish. U.S. Environmental Protection Agency, Duluth, Minnesota, Publication No. EPA-600/3-79-088. 106 pp.

Procedures were developed to clinically evaluate liver damage and liver function in rainbow trout following either acute intraperitoneal (i.p.) treatment or subacute bath exposure to selected mammalian hepatotoxic agents. Elevations in serum of liver specific enzymes such as aspartate aminotransferase (GOT), alanine aminotransferase (GPT) and alkaline phosphatase (AP) were investigated as potential indicators of hepatocellular damage. An exogenous test of liver function, plasma clearance of the organic anion sulfobromophthalein (BSP), also was investigated as a potentially useful test of overall liver function in the trout.

The application of clinical tests to diagnose liver dysfunction in fishes following their exposure to environmental toxicants may be practical in controlled laboratory facilities. Despite the considerable variation that exists between groups of fish, significant differences could be demonstrated between control and treated fish. Variation among groups of fish make intergroup comparison of the field populations increasingly difficult by these methods. Therefore, the use of such techniques should be employed to evaluate liver toxicity under precisely controlled laboratory studies. Their application to field studies does not seem advisable.

Hydroscience, Inc. 1979. Great Lakes Environmental Planning Using Limnological Systems Analysis: Phase I - Preliminary Model Design. U.S. Environmental Protection Agency, Duluth, Minnesota, Publication No. EPA-600/3-79-011b. 458 pp.

The report documents the deliberate decision making process used by the Great Lakes Basin Commission in concluding that rational modeling methodologies could be used to evaluate the effect of different planning alternatives on the Great Lakes and that planning for specific problems affecting the Great Lakes system can be technically and economically supported through mathematical modeling and systems analysis. It assesses the technical and economical feasibility of developing mathematical models to assist in making selections from among alternative management strategies and structural solutions proposed for solving water resource problems of the Great Lakes. The study reviews, evaluates and categorized present and future water resources problems, presently available data, problem-oriented mathematical models and the state of models and model synthesis for large lakes. A demonstration modeling framework for planning is developed and applied to western Lake Erie and the Great Lakes system. The report evaluates four widely ranging alternatives for future modeling efforts in the Great Lakes and recommends the modeling level most feasible to answer planning questions on scales ranging from the Great Lakes to regional areas. Also discussed is a proposed Commission study which will apply limnological systems analysis to the planning process.

Hydroscience, Inc. 1979. Great Lakes Environmental Planning Using Limnological Systems Analysis: Model Specifications. U.S. Environmental Protection Agency, Duluth, Minnesota, Publication No. EPA-600/3-79-011c. 43 pp.

The report documents the deliberate decision making process used by the Great Lakes Basin Commission in concluding that rational modeling methodologies could be used to evaluate the effect of different planning alternatives on the Great Lakes and that planning for specific problems affecting the Great Lakes system can be technically and economically supported through mathematical modeling and systems analysis. It assesses the technical and economical feasibility of developing mathematical models to assist in making selections from among alternative management strategies and structural solutions proposed for solving water resource problems of the Great Lakes. The study reviews, evaluates and categorized present and future water resources problems, presently available data, problem-oriented mathematical models and the state of models and model synthesis for large lakes. A demonstration modeling framework for planning is developed and applied to western Lake Erie and the Great Lakes system. The report evaluates four widely ranging alternatives for future modeling efforts in the Great Lakes and recommends the modeling level most feasible to answer planning questions on scales ranging from the Great Lakes to regional areas. Also discussed is a proposed Commission study which will apply limnological systems analysis to the planning process.

Lin, C. K., and C. L. Schelske. 1979. Effects of Nutrient Enrichment, Light Intensity, and Temperature on Growth of Phytoplankton from Lake Huron. U.S. Environmental Protection Agency, Duluth, Minnesota, Publication No. EPA-600/3-79-049. 64 pp.

> This report contains a seasonal study on effects of nutrient enrichment, light and temperature on the growth of natural phytoplankton and three species of cultured diatoms. Natural phytoplankton assemblages collected monthly from April to December 1975, in southern Lake Huron were used for ten sets of bioassays by adding nutrients in 18 combinations directly to lake water samples. Nutrients tested were phosphorus, nitrogen, silica, EDTA, trace metals and vitamins. Responses to different treatments evaluated by chlorophyll production and cell counts were complex and varied sasonally. Nitrogen had the least effect and phosphorus the greatest effect on chlorophyll production. Silica deleted from a complete enrichment usually had a relatively small effect on chlorophyll production but did affect the proportion of diatoms. Deletion of EDTA and Fe-EDTA reduced chlorophyll production greatly in comparison to the complete treatment. Deleting trace metals had a small effect, but deleting trace metals and EDTA reduced chlorophyll production significantly during the summer. Growth of winter phytoplankton increased with temperature and light intensity with most species being eurythermal, except *Cyclotella comensis* and *C. stelligera* which grew best at 10°C. Uptake ratios of P, N and Si varied with temperature and light. Specific growth rates for three diatoms, *Diatoma tenue* var. *elongatum*, *Fragilaria crotonensis* and *Asterionella formosa*, isolated from the Great Lakes were determined in separate light and temperature gradient experiments.

Patterson, R. L. 1979. Production, Mortality, and Power Plant Entrainment of Larval Yellow Perch in Western Lake Erie. U.S. Environmental Protection Agency, Duluth, Minnesota. Publication No. EPA-600/3-79-087. 187 pp.

> This study assessed impacts of the Monroe Power Plant upon the yellow perch population of Western Lake Erie caused by entrainment and impingement of larvae and older fishes in the plant's open cycle cooling system in 1975-76. Data analyzed in the study were collected by the Michigan Department of Natural Resources, the Center for Lake Erie Area Research of the Ohio State University, and the Institute of Water Research of Michigan State University. Estimates of total numbers of perch larvae entrained, total perch production, the natural mortality rate of perch, and the percentage of perch production that was entrained by the Monroe Power Plant were obtained for 1975-76. Impingement estimates were obtained from data supplied by the power plant. The above estimates consider only effects that occur in the same year in which entrainment and impingement occurs. Impacts may occur in subsequent years which include a depression of fish stocks and reduced yields to the fishery. Losses to the standing stocks and fisheries were estimated using a method which falls into a category known as the "equivalent-adult" type which provided estimates of the long-run annual

depression of yellow perch standing stocks and the yellow perch fisheries. A numerical model was developed which incorporated several population parameters including entrainment and impingement losses; natural mortality rates for larvae, young-of-year, and juveniles; and fishing motality rates.

Paul, J. F., W. L. Richardson, A. B. Gorstko, and A. A. Matveyev. 1979. Results of a Joint U.S.A./U.S.S.R. Hydrodynamic and Transport Modeling Project. U.S. Environmental Protection Agency, Duluth, Minnesota, Publication No. EPA-600/3-79-015. 90 pp.

A joint modeling project with scientists from the U.S.A. and U.S.S.R. has been accomplished. The three geographical areas investigated include Lake Baikal and the Sea of Azov in the U.S.S.R. and Saginaw Bay, Lake Huron in the U.S.A. The modeling approaches ranged from those employing material and mass conservation to describe water movement to those involving solution of the complete three-dimensional hydrodynamic equations. The model calculations were compared to available data and, in all cases, reasonable agreement was obtained. This report covers a period from May 1977 to December 1977, and work was completed as of April 1978.

Paul, J. F., W. L. Richardson, A. B. Gorstko, and A. A. Matveyev. 1979. Results of a Joint U.S.A./U.S.S.R. Hydrodynamic and Transport Modeling Project Appendices B, C, and D. U.S. Environmental Protection Agency, Duluth, Minnesota, Publication No. EPA-600/3-79-101. 250 pp.

A joint modeling project with scientists from the U.S.A. and U.S.S.R. has been accomplished. The three geographical areas investigated include Lake Baikal and the Sea of Azov in the U.S.S.R and Saginaw Bay, Lake Huron in the U.S.A. The modeling approaches ranged from those employing material and mass conservation to describe water movement to those involving solution of the complete three-dimensional hydrodynamic equations. The model calculations were compared to available data and, in all cases, reasonable agreement was obtained. This portion of the report includes Appendices B, C, and D for the main study published as EPA-600/3-79-015. This report covers a period from May 1977 to December 1977, and work was completed as of April 1978.

Skogerboe, R. K., C. S. Lavallee, M. M. Miller, and D. L. Dick. 1979. Environmental Effects of Western Coal Surface Mining. Part III - The Water Quality of Trout Creek, Colorado. U.S. Environmental Protection Agency, Duluth, Minnesota, Publication No. EPA-600/3-79-008. 58 pp.

Water quality parameters have been measured at several on-stream and off-stream sites along Trout Creek, which is recipient of water from coal strip-mining operations. Levels of the gross parameters (e.g., specific conductivity), the common ions (e.g., calcium and sulfate), and some trace components (e.g., selenium) are highest in mine spoil drainages.

The impact of the mine spoil drainage on the stream is reflected in the larger quantities of dissolved solids and common ions found at on-stream sites adjacent to and below the mine. For trace elements, the mine operation has no detectable impact on Trout Creek in terms of increasing concentrations of Al, As, Cd, Cr, Cu, Fe, Pb, or Zn. Increases in stream concentrations of Mn and Se due to mine inflow can be inferred from the data. Higher concentrations of As, Fe, Mn, Se, and Zn are found in waters draining mine spoils. In the mine spoils, variations in the concentrations of these elements occur with spoil age; more Mn and Zn occur in older spoils, while higher levels of As, Fe, and Se are found in newer spoils.

Chemical equilibrium calculations indicate that alkaline precipitation processes can maintain the low concentrations of Al, Cd, Cu, Fe, Pb, and Zn. The general alkaline characteristics of western streams and aquifers suggests that such precipitation equilibria will limit the soluble heavy metal concentrations.

Skogerboe, R. K., C. S. Lavallee, M. M. Miller, and D. L. Dick. 1979. Environmental Effects of Oil Shale Mining and Processing. Part III - The Water Quality of Piceance Creek, Colorado, Prior to Oil Shale Processing. U.S. Environmental Protection Agency, Duluth, Minnesota. Publication No. EPA-600/3-79-055. 59 pp.

Water quality data have been collected at seven sites along Piceance Creek and at one site each along Stewart, Black Sulphur, and Yellow Creeks in the Piceance Basin, Colorado, during 1975-1977. Piceance, Stewart, and Yellow Creeks may be perturbed by oil shale industry activities on the two tracts, C-a and C-b, currently under development. The preoperational water quality is generally poor due to higher levels of dissolved solids (contributed to by calcium, magnesium, sodium, bicarbonate, sulfate, chloride, and potassium), manganese, and both dissolved and suspended iron. The quality of water along Piceance Creek also declined at sites farther downstream primarily due to influxes from groundwater aquifers in contact with soluble mineral beds. The highest concentrations of the most common ions were observed in June-August due to the combined effects of irrigation, evapotranspiration, and minimal surface runoff contributions.

The concentrations of aluminum, cadmium, chromium, lead, and boron were below the detection limits of the analysis method used. These were typically below the permissible levels set for aquatic life by factors of 5-10. The levels of copper, zinc, arsenic, selenium, and mercury were usually measurable but still below permissible levels. The levels of copper, zinc, and mercury were similar at all sites along Piceance Creek. The levels of arsenic, suspended iron, and manganese were highest at the downstream limit of sampling; the level of selenium showed the opposite trend.

Equilibrium calculations indicate that the natural conditions along Piceance Creek—in particular the alkaline pH range 97.5-8.5) and high carbonate alkalinity (300-800 mg $CaCO_3$/l)—should limit the solubilities of most metals to levels below the criteria standards set in protection of aquatic life.

Smith, L. L., Jr., S. J. Broderius, D. M. Oseid, G. L. Kimball, W. M. Koenst, and D. T. Lind. 1979. Acute and Chronic Toxicity of HCN to Fish and Invertebrates. U.S. Environmental Protection Agency, Duluth, Minnesota, Publication No. EPA-600/3-79-009. 115 pp.

Acute and chronic toxicity of hydrogen cyanide to seven fish species and two invertebrates was determined in dynamic flow-through bioassays. The 96-hr LC50 concentrations of HCN for juvenile fish ranged from 57 μg/l for rainbow trout at 10°C to 191 μg/l for field stock fathead minnows at 15°C. The fry and juvenile fish were similar in their sensitivity to HCN with eggs the most tolerant stage. The 96-hr LC50 concentrations for invertebrates ranged from 176 μg/l for Gammarus to 2328 μg/l for Asellus at 18°C. Long-term tests conducted with fathead minnows demonstrated that the concentrations of HCN having no adverse effect on egg production was between 12.9 and 19.6 μg/l. Chronic tests with brook trout demonstrated that on the basis of spawning success the maximum acceptable toxicant concentration (MATC) was between 5.7 and 11.2 μg/l HCN. Long-term tests with bluegills showed that no spawning occurred at HCN concentrations as low as 5.2 μg/l. Chronic experiments with invertebrates demonstrated that the highest concentration of HCN having no adverse effect was between 29 and 40 μg/l for Asellus and between 16 and 21 μg/l for Gammarus. Experiments conducted with intermittent and sublethal diurnal exposure regimes demonstrated that adverse effects of early growth of the fathead minnow are lessened as the exposure period is reduced. Using the toxic unit approach, it also was demonstrated that the Zn-HCN and ammonia-HCN mixtures were more acutely toxic and the Cr-HCN mixture less toxic than what would be predicted from simply additive interaction. This report covers a period from November 1, 1973 to September 30, 1978.

Stemberger, R. S., J. E. Gannon, and F. J. Bricker. 1979. Spatial and Seasonal Structure of Rotifer Communities in Lake Huron. U.S. Environmental Protection Agency, Duluth, Minnesota. Publication No. EPA-600/3-79-085. 160 pp.

This report presents comprehensive data on species composition and distribution of planktonic rotifers in Saginaw Bay and southern Lake Huron from April to November, 1974. Rotifer species composition and abundance differed greatly between Saginaw Bay and open Lake Huron waters. Through cluster analyses, these differences were empirically related to the physicochemical environment. The results of these analyses suggest that rotifers are valuable organisms in water quality assessment studies. Several species which displayed distribution limited to eutrophic Saginaw Bay stations or to oligotrophic offshore Lake Huron stations were potentially useful as environmental indicators. Based on rotifer data, the greatest impact of Saginaw Bay waters on Lake Huron occurred along the western shore of southern Lake Huron below the mouth of the bay. In general, inshore stations of southern Lake Huron displayed greater rotifer abundance than mid-lake stations.

Certain rotifers displayed distinct epilimnetic or hypolimnetic vertical distributions. However, maxima of total rotifer abundance usually occurred in the vicinity of the metalimnion. Wind-generated turbulence often distributed rotifers more evenly in the epilimnion.

Thomann, R. V., R. P. Winfield, and J. J. Segna. 1979. Verification Analysis of Lake Ontario and Rochester Embayment Three Dimensional Eutrophication Models. U.S. Environmental Protection Agency, Duluth, Minnesota, Publication No. EPA-600/3-79-094. 136 pp.

A three dimensional time variable model of the phytoplankton and nutrients of Lake Ontario and the Rochester Embayment is examined in detail. The data from the International Field Year on the Great Lakes (IFYGL) are used as the primary data base. The data are summarized and statistically analyzed on a three dimensional grid and segment averages using a 67 segment representation of the lake and a 72 segment representation of Rochester Embayment, are calculated. In addition, averages for eight regions of the lake and lakewide averages for two depth layers are computed. Average phytoplankton levels during the period May, 1972 and June, 1973 in the near shore region are approximately 3 μg/l higher than open lake values. Similarly, near shore open lake total phosphorus gradients of about 5 μg P/l appear to persist for a substantial part of the year. The data base collected during IFYGL exhibited significant spatial and temporal variations at scales of 10 x 40 km. The two data bases available, Canadian Centre for Inland Waters (CCIW) and Environmental Protection Agency (EPA), only agree within certain limits.

Thurston, R. V., R. C. Russo, and K. Emerson. 1979. Aqueous Ammonia Equilibrium - Tabulation of Percent Un-Ionized Ammonia. U.S. Environmental Protection Agency, Duluth, Minnesota, Publication No. EPA-600/3-79-091. 428 pp.

The percent of un-ionized ammonia as a function of pH and temperature in aqueous ammonia solutions of zero salinity is presented in tabular form over the following ranges: temperature 0.0 to 40.0 C in increments of 0.2 degree, and pH 5.00 to 12.00 in increments of 0.01 pH unit.

Turbak, S. C., G. J. Olson, and G. A. McFeters. 1979. Environmental Effects of Western Coal Surface Mining. Part IV - Chemical and Microbiological Investigations of a Surface Coal Mine Settling Pond. U.S. Environmental Protection Agency, Duluth, Minnesota, Publication No. EPA-600/3-79-125. 70 pp.

Chemical and microbiological investigations of the settling pond system at the West Decker Coal Mine in southeastern Montana were undertaken during an 18-month period from November 1975 to April 1977. West Decker is one of the largest surface coal mines in the United States. Extensive chemical analysis of pond water samples during a portion of ths period revealed that coal mining in the Decker area may be impacting groundwater quality since the pond water differed chemically from surrounding groundwaters. Concentrations of total dissolved solids, bicarbonate, sodium, sulfate, and nitrogen species in pond water were elevated in comparison to those in other nearby surface waters; however, it was concluded that these would not significantly impact the Tongue River or Tongue River Reservoir. Constituents of the mine drainage waters underwent chemical changes within the pond which were at least in part due to the activities of microorganisms. The increase in pH value and in concentration of dissolved oxygen, partially attributed to photosynthesis within the pond, oxidized reduced chemical species such as sulfide and ferrous iron. The high numbers and activity measurements of sulfate reducing bacteria as well as the significant amount of metal-bound sulfides in pond sediments made a strong case for the contributions of these organisms to metal precipitation in, and possible detoxification of, pond waters. Acidophilic iron and sulfur bacteria, responsible for the production of acid mine drainage, were consistently detected within the pond system and other locations at Decker. However, no acidic conditions were observed, most likely because relatively high concentrations of mineral carbonate in the overburden of neutralized acid formed from pyritic materials present.

Waybrant, R. C., and J. M. Shauver. 1979. Survey of Larval Fish in the Michigan Waters of Lake Erie, 1975 and 1976. U.S. Environmental Protection Agency, Duluth, Minnesota, Publication No. EPA-600/3-79-095. 86 pp.

Surveys in 1975 and 1976 in the Michigan waters of Lake Erie assessed the relative abundance and distribution of larval fish.

Seasonal fluctuations, patterns of distribution, and depth preferences were noted for the 24 larval fish taxa identified. Special emphasis was placed on four target species, walleye (Stizostedion vitreum), yellow perch (Perca flavescens), white bass (Morone chrysops) and channel catfish (Ictalurus punctatus). Of these 4 species only yellow perch and white bass were found more than occasionally.

Of the remaining 20 species collected during the study only 5 (shiners - Notropis atherinoides, N. hudsonius, alewives, gizzard shad, and rainbow smelt) were regularly captured. The clupeids (alewives and gizzard shad) were the most abundant species collected during both years (84% of all fish collected in 1975 and 85% in 1976) with shiners the second most abundant (5.5%) and rainbow smelt (4.4%) least abundant of these five species.

The northern and southern extremes of the study area held many more fish than the central portion. The 0- to 12-ft depth zone had the largest concentrations of larval fish and concentrations gradually decreased as the depth increased.

Wrenn, W. B., B. J. Armitage, E. B. Rodgers, T. D. Forsythe, and K. L. Grannemann. U.S. Environmental Protection Agency, Duluth, Minnesota, Publication No. EPA-600/3-79-092. 172 pp.

Effects of long-term temperature elevations on aquatic communities in 12 outdoor experimental channels were evaluated during the period March-September 1977. Macroinvertebrates, periphyton, and zooplankton colonized the channels naturally from the water supplied from Wheeler Reservoir, Tennessee River. The fish community consisted of stocked adult bluegill and juvenile walleye. Four temperature regimes, with three replicate channels per regimen, were maintained. The ambient temperature of the water pumped from Wheeler Reservoir provided the lowest treatment. Elevated regimens of ca. 2°, 4°, and 6° C above ambient were maintained in the remaining nine channels.

1980

JOURNAL ARTICLES, BOOK CHAPTERS, PROCEEDINGS, ETC.

Anderson, R. L. 1980. Chironomidae Toxicity Tests -- Biological Background and Procedures. Aquatic Invertebrate Bioassays, ASTM STP 715 (A. L. Buikema, Jr., and J. Cairns, Jr., eds.), pp. 70-80, American Society for Testing and Materials. ERL-D Reprint #232.

> Toxicity tests must be based on an understanding of the test animal's life cycle. The first section of this report describes the biological information needed to develop toxicity test procedures. The second section describes three categories of toxicity test systems - short-exposure, partial life-cycle, and life-cycle exposures.
>
> Each researcher has developed a procedure to solve a particular problem. Therefore, it is impossible to provide specific recommendations for a general toxicity test. In practice, anyone using chironomids should establish a clear experimental objective and then select the test species. The required biological information and test procedure can then be obtained from the literature or developed by experimentation.

Anderson, R. L., and D. L. DeFoe. 1980. Toxicity and Bioaccumulation of Endrin and Methoxychlor in Aquatic Invertebrates and Fish. Environ. Pollut. (Series A) 22: 111-121. ERL-D Reprint #227.

> Stoneflies, caddis-flies, isopods, snails, and bullheads were exposed to endrin or methoxychlor in a flowing-water test system for 28 days. Endrin was more toxic than methoxychlor. Behavior changes in the caddis-fly *Brachycentrus americanus* and in the stonefly *Pteronarcys dorsata* were observed within 4 days at 0.07 and 0.15 μg/l of endrin, respectively. The LC50 values decrease with increasing exposure times. The 28-day LC50 was less than 0.03 μg/l for *B. americanus* and 0.07 μg/l for *P. dorsata*. The 28-day LC50 for the bullhead *Ictalurus melas* was 0.10 μg/l.
>
> Methoxychlor, at the concentrations tested, did not affect all the species. The isopod *Asellus communis* was the most sensitive; behavioral changes occurred within the first 4 days. The 28-day LC50 was 0.42 μg/l. The LC50 for the caddis-fly *Hydropsyche* sp. decreased from 2.9 μg/l at 14 days to 1.3 μg/l at 28 days. The stonefly *P. dorsata* and the snail *Physa integra* did not die at the highest concentration tested (4.2 μg/l), although behavioral changes were seen at 2.2 μg/l for the stonefly.

Pesticide accumulation was determined in the stoneflies and snails that survived the exposures. Stoneflies accumulated methoxychlor and endrin to concentrations 350 to 1150 times greater than the water concentrations. The snail concentration factors for methoxychlor ranged from 5000 to 8600.

Anderson, R. L., C. T. Walbridge, and J. T. Fiandt. 1980. Survival and Growth of Tanytarsus dissimilis (Chironomidae) Exposed to Copper, Cadmium, Zinc, and Lead. Arch. Environ. Contam. Toxicol. 9: 329-335. ERL-D Reprint #220.

Tanytarsus dissimilis (Johannsen) was exposed to four heavy metals. Static exposure began during embryogenesis and continued through hatching and larval development to the 2nd and 3rd instar. The LC50 concentrations for cadmium, copper, and zinc were 3.8, 16.3, and 36.8 µg/l, respectively. The LC50 for lead was 258 and zinc were 3.8, 16.3, and 36.8 µg/l, respectively. The LC50 for lead was 258 µg/l. Growth was not reduced at exposure concentrations less than the LC50.

The LC50 concentrations obtained in this insect exposure are as much as 1,600 times lower than other insect exposures reported in the literature. This is probably due to a combination of exposure of this insect during important life cycle events and species-specificity.

Arthur, J. W. 1980. Review of Freshwater Bioassay Procedure for Selected Amphipods. IN: Aquatic Invertebrate Bioassays, ASTM STP 715 (A. L. Buikema, Jr., and John Cairns, Jr., eds.), pp. 98-108, American Society for Testing and Materials. ERL-D Reprint #233.

Methods previously used for performing gammarid bioassays and several important life-cycle requirements are reviewed. The discussion is largely based on methodology for the amphipods Gammarus fasciatus, Gammarus lacustris, and Gammarus pseudolimnaeus, but additional evidence, gathered from other selected freshwater crustacean tests, is included. The survival rate, acclimation period, test chamber size, and age of the amphipods are discussed for short-term tests. The survival rate, isolation versus nonisolation of gravid females, sex ratios during the reproductive period, and test duration are considered for the long-term tests. Primary emphasis should be placed on flow-through methods. The particular problem under investigation will ultimately determine the methods and species required. At present, the choice of species may be G. lacustris because a higher success in laboratory culturing has been achieved for this species, and more information is available about its life-cycle requirements.

Auer, M. T., and R. P. Canale. 1980. Phosphorus Uptake Dynamics as Related to Mathematical Modeling of Cladophora at a Site on Lake Huron. J. Great Lakes Res. 6(1): 1-7.

Cladophora is a significant symptom of eutrophication in Lakes Erie and Ontario and is a local problem associated with nutrient perturbations in Lakes Huron, Michigan, and Superior. This paper presents results of measurements of phosphorus uptake rates as a function of internal phosphorus levels by Cladophora growing near Harbor Beach, Michigan. Cladophora collected near the Harbor Beach wastewater treatment plant had high levels of internal phosphorus and low (or even negative) phosphorus uptake rates. Cladophora distant from the wastewater treatment plant had low internal phosphorus levels and rapid phosphorus uptake rates. The experimental results are discussed in terms of quantitative kinetic formulations which may be incorporated into mathematical models useful for predicting the response of Cladophora to alternative management and control strategies. Preliminary model simulations of Cladophora biomass, internal phosphorus, and external phosphorus are qualitatively similar to observed field data.

Auer, M. T., R. P. Canale, Y. Matsuoka, and H. C. Grundler. 1980. Modeling the Response of the Nuisance Alga, Cladophora glomerata, to Reductions in Phosphorus Loading. IN: Restoration of Lakes and Inland Waters, International Symposium on Inland Waters and Lake Restoration, September 8-12, 1980, Portland, Maine.

The mathematical model was developed to evaluate the impact of various phosphorus management strategies on nuisance growths of the filamentous alga Cladophora glomerata. The model was supported by intensive ecological studies and an extensive field monitoring program. The results of simulating spatial and seasonal variation in algal biomass and associated nutrient parameters agree well with field observations. The calibrated model is used to predict the response of the system under study to a demonstration phosphorus removal program. Implications to large scale phosphorus management strategies are discussed.

Baker, J. R., and T. F. Jordan. 1980. Vertical-Structure Functions for Time-Dependent Flow in a Well-Mixed Fluid with Turbulent Boundary Layers at the Bottom and Top. J. Phys. Oceanogr. 10(10): 1691-1694.

The elements of an eigenfunction expansion for time-dependent currents as a function of depth are worked out for viscosity that is given as a parabolic function of depth that goes to zero at both the bottom and top of the water. This yields currents with logarithmic behavior characteristic of turbulent boundary layers at both the bottom and top. Also, solutions are obtained for the two viscosity functions that are half a parabola, going to zero at either the bottom or top but not both. In all cases the solutions are Legendre functions. In some cases the eigenfunctions are Legendre polynomials.

Bierman, V. J., Jr., D. M. Dolan, E. F. Stoermer, and V. E. Smith. 1980. The Development and Calibration of a Spatially Simplified Multi-Class Phytoplankton Model for Saginaw Bay, Lake Huron. Great Lakes Environmental Planning Study (GLEPS), Contribution No. 33.

> The purpose of the modeling effort was to develop a deterministic phytoplankton simulation model that could describe the cause-effect connection between external nutrient loading and phytoplankton growth in Saginaw Bay. The emphasis in the present report is on the research aspects of the model development and calibration. In this context, model development is seen as providing a quantitative framework for organizing and interpreting experimental data. The calibrated model is seen as providing a tool for testing different hypotheses on a whole-system scale.

Cairns, J., Jr., and K. W. Thompson. 1980. A Computer Interfaced Toxicity Testing System for Simulating Variable Effluent Loading. IN: Second Symposium on Process Measurements for Environmental Assessment (P. L. Levins et al., eds.), pp. 183-198, Arthur D. Little, Inc., Cambridge, Massachusetts.

> Water quality criteria and standards are based primarily on toxicity tests carried out with single chemicals whose concentration is as nearly constant as possible. In the "real world", however, organisms are exposed to mixtures of chemicals which usually have markedly fluctuating concentrations. The primary difficulties in simulating "real world" conditions in toxicity testing are: (a) a means of varying chemical concentration to fit a predetermined set of conditions, and (b) a system which is capable of tracking and recording the response of aquatic organisms to these variations and which is quantitative and suitable for cross correlations of dose and response. Mini- and microcomputer interfacing with a toxicity testing system provides a means of systematically varying the concentration of a test chemical or chemicals in a continuous flow system. The same computer can also be used for the data acquisition system to store the voluminous time-series biological response data necessary for cross correlations with variable chemical concentrations. A description of the apparatus, examples of its use, types of data generated, and data analysis are discussed.

Carlson, A. R., J. Blocher, and L. J. Herman. 1980. Growth and Survival of Channel Catfish and Yellow Perch Exposed to Lowered Constant and Diurnally Fluctuating Dissolved Oxygen Concentrations. Prog. Fish-Cult. 42(2): 73-77. ERL-D Reprint #225.

> Growth and survival were determined for duplicate lots of juvenile channel catfish (*Ictalurus punctatus*) and yellow perch (*Perca flavescens*) exposed for 69 and 67 days, respectively, to nearly constant dissolved oxygen (DO) concentrations at near air saturation (control), 6.5, 5.0, 3.5, and 2.0 mg/l. The following year juveniles of the same

species were exposed to DO concentrations that gradually fluctuated diurnally at about 1.0 to 1.5 mg/l above and below the constant lowered DO levels of the previous year. At mean constant DO concentrations of 3.5 mg/l or less, channel catfish consumed less food and growth was significantly reduced ($P = 0.05$). Growth was not impaired by mean fluctuations of about 6.2 to 3.6 and 4.9 to 2 mg/l, but was significantly reduced at fluctuations of about 3.1 to 1.0 mg/l. Similarly, at mean constant DO concentrations near 3.5 mg/l, yellow perch consumed less food but growth was not affected; at 2.0 mg/l less food was consumed and growth was significantly reduced ($P = 0.05$). Growth was not affected by fluctuations of about 3.8 to 1.4 mg/l. Survival of both species was unaffected by the reduced DO exposures.

Christensen, G. M., and B. L. Riedel. 1980. An Enzyme-Immobilization Procedure for the Analysis of Enzyme-Inhibiting Chemicals in Water. Intern. J. Environ. Anal. Chem. 8: 277-282. ERL-D Reprint #238.

The enzymes cholinesterase and urease were mixed individually with gelatin and immobilized into the inside surface of glass capillary tubes. After the gelatin-enzyme mixture had dried, water samples containing various enzyme inhibiting test chemicals were pumped through the tubes to enable interaction to proceed between the foreign agents and the enzymes. Substrate for each enzyme was later passed through the tubes and any difference in relative enzyme activity determined. This procedure may be useful for health and environmental studies, particularly in the rapid testing for micro- and nanomolar quantities of enzyme-inhibiting pollutants in natural waters and complex effluents.

Dempsey, B. A., and P. C. Singer. 1980. The Effects of Calcium on the Adsorption of Zinc by $MnO_x(s)$ and $Fe(OH)_3(am)$. IN: Contaminants and Sediments, Volume 2, Chapter 18, (R. A. Baker, ed.), pp. 333-352, Ann Arbor Science Publishers, Ann Arbor, Michigan.

The objectives of this study were to investigate the adsorption of Zn and Ca on selected model hydrous oxide surfaces and to evaluate the influence of Ca adsorption as a control mechanism for the adsorption of Zn. The adsorbing surfaces investigated MnO_x and $Fe(OH)_3(am)$ because these solids are environmentally significant solid phases in natural waters and they represent a reasonable variation in pH_{zpc} and ε_{solid} values. It was shown that for the Zn and Ca concentrations used, large concentrations of Ca did prevent absorption of trace concentrations of Zn by MnO_x or $Fe(OH)_3(am)$. Competition appeared to be insignificant on $Fe(OH)_3(am)$ under all conditions tested. Competition became insignificant on MnO_x at pH values greater than 7.0. Concentrations of MnO_x and $Fe(OH)_3(am)$ in natural waters are expected to be lower than the concentrations used in these tests. Extrapolation to lower adsorbent concentrations involves some assumptions, since none of the available models has been verified over a wide range of concentrations in adsorbent and adsorbate. Nevertheless, the models described in this chapter have been used to predict adsorption of 10^{-7} M Zn_T by 10^{-7}, 10^{-6}, 10^{-5} and 10^{-4} M MnO_x or $Fe(OH)_3(am)$.

DiToro, D. M. 1980. The Effect of Phosphorus Loadings on Dissolved Oxygen in Lake Erie. IN: Phosphorus Management Strategies for Lakes, Chapter 8, (R. C. Loehr et al., eds.), pp. 191-205, Ann Arbor Science, Ann Arbor, Michigan.

The purposes of this chapter are to summarize the methods used to analyze the present effects of phosphorus discharges on the dissolved oxygen distribution of Lake Erie and to present the results of calculations which attempt to predict the impact of phosphorus loading reductions.

Dougherty, R. C., M. J. Whitaker, L. M. Smith, D. L. Stalling, and D. W. Kuehl. 1980. Negative Chemical Ionization Studies of Human and Food Chain Contamination with Xenobiotic Chemicals. Environ. Health Perspect. 36: 103-118. ERL-D Reprint #235.

Negative chemical ionization mass spectrometry with a mixture of isobutane, methylene chloride, and oxygen as the reagent gas has been used to explore contamination of environmental substrates with xenobiotic chemicals. The substrates in question, fish tissue, human seminal plasma, and human adipose tissue, were cleaned up by one of the following three cleanup procedures: (1): continuous liquid-liquid extraction steam distillation; (2) gel-permeation chromatography; and (3) adsorption on activated carbon followed by elution with toluene. The third procedure was used only for the examination of planar polychlorinated aromatic hydrocarbons in environmental samples. Using these techniques, we have found evidence for contamination of fish samples with polychloronaphthalenes, polychlorostyrenes, polychlorobiphenyls, polychlorodibenzofurans, and polychlorodibenzodioxins among other chemicals. The polychlorodibenzodioxins appeared only in the spectra of extracts of fish obtained from the Tittabawassee River at Midland, Michigan. The polychlorodibenzofuran ions appeared in NCI mass spectra of fish that were significantly contaminated (above 2 ppm) with polychlorobiphenyls. Toxic substances occurring in human seminal plasma included pentachlorophenol, hexachlorobenzene, DDT metabolites, and polychlorobiphenyls. We have investigated toxic substances in human seminal plasma because of the apparent decrease in sperm density in U.S. males of the last 30 years.

Results of screening human adipose tissue for contamination with xenobiotic chemicals have been largely coincident with results of the EPA human monitoring program. Polychlorobiphenyls, DDT metabolites, nonachlor, and chlordane have appeared in most samples examined. Detection limits for all of these chemicals were of the order of 1 ppb.

Dougherty, R. C., M. J. Whitaker, S. Y. Tang, R. Bottcher, M. Keller, and D. W. Kuehl. 1980. Sperm Density and Toxic Substances: A Potential Key to Environmental Health Hazards. IN: Environmental Health Chemistry, Environmental Analysis, Chapter 13, (J. D. McKinney, ed.), pp. 263-278, Ann Arbor Science Publishers, Inc. ERL-D Reprint #239.

> Negative chemical ionization mass spectrometry and micro-scale continuous liquid-liquid extraction steam distillation have been used to screen for toxic substances in human seminal plasma from 132 college-aged males. Polychlorinated phenols, PCBs, hexachlorobenzene, DDT metabolites and polychlorinted naphthalenes, as well as a number of unknown polychlorinated substances were identified in the samples. Using multiple linear regression, PCBs uniformly gave negative slope correlations with sperm density.

Eisenreich, S. J. 1980. Atmospheric Input of Trace Metals to Lake Michigan. Water, Air, Soil Pollut. 13: 287-301.

> Atmospheric bulk deposition was collected on a monthly basis in the Lake Michigan basin from September 1975 through December 1976 to determine the atmospheric loading of trace elements to Lake Michigan. The sampling network consisted of bulk collectors located at 21 locations in the northern and southern basin. Atmospheric loading rates to Lake Michigan were estimated as (in units of 10^5 kg yr^{-1}): Al-50; Fe-28; Mn-6.4; Zn-11; Cu-1.2; Pb-6.4; Cd-0.11; Co-<0.25; Ca-798; Mg-155; Na-110; K-64. Atmospheric deposition of all elements measured was greater in the southern basin than in the northern basin as a result of intense urban/industrial activity in the former. The percentage of total atmospheric deposition falling in the southern basin was: Fe-74%, Al-71%; Mn-75%; Zn-67%; Cu-62%; Pb-78%; Cd-74%; Co--56%; Ca-79%; Mg-62%; Na-65%; K-61%. Atmospheric loading rates reported are in general agreement with estimates made by others from emission inventories and aerosol concentrations. Atmospheric loadings were estimated to represent 10% or more of the total loadings to Lake Michigan from tributary and erosion sources for the trace elements Mn, Zn, Cu, Cd and Pb. Also, atmospheric deposition may account for recent accumulations of Zn, Cu, Cd, Pb and Co in southern Lake Michigan surficial sediments. The atmospheric Pb flux to southern Lake Michigan was estimated as 1.7 µg cm^{-2} yr^{-1} for 1975-1976 which compares favorably with the 1972 anthropogenic Pb flux of 1.3 µg cm^{-2} yr^{-1} (total - ~1.5 g cm^{-2} yr^{-1}) as determined from Pb-210 dating (Edington and Robbins, 1976). The geographical distribution of trace element loading implicates the southern periphery of Lake Michigan as the principal emission source area.

Eisenreich, S. J., G. J. Hollod, T. C. Johnson, and J. Evans. 1980. Polychlorinated Biphenyl and Other Microcontaminant-Sediment Interactions in Lake Superior. IN: Contaminants and Sediments, Volume 1, Chapter 4, (R. A. Baker, ed.), pp. 67-94, Ann Arbor Science Publishers, Inc., Ann Arbor, Michigan.

Careful examination of sediment profiles for PCBs and Pb-210 in Lake Superior indicates that PCB fluxes to the sediment have been highest in the last 10-15 years and vary from 0-185 $\mu g/m^2/yr$, with a mean value of 60 $\mu g/m^2/yr$. PCB sediment profiles also show bioturbation depths to 0.25-5 cm. The net effect of PCB fluxes to the sediment and mixing due to bioturbation is to increase the exposure time of sedimentary PCBs to the overlying water and biotic activity following input abatement. The time required for PCB burial in the sediments to 5 cm at sedimentation rates of ~0.03 cm/yr is ~167 years, close to the hydraulic residence time of the lake. Since the importance of biotic recycling of sedimentary PCBs has already been established for Lake Michigan, Lake Superior sediments must be considered an important source of PCBs to the biota and overlying water. The effect of partial reduction of PCB inputs to the lake would not be seen in sedimentary accumulations for ~30-50 years.

Fisher, J. B., W. J. Lick, P. L. McCall, and J. A. Robbins. 1980. Vertical Mixing of Lake Sediments by Tubificid Oligochaetes. J. Geophys. Res. 85(C7): 3997-4006.

> Vertical mixing of lake sediments by tubificid oligochaetes was studied in laboratory experiments by using a radioactive (cesium 137 labeled sediment) marker horizon. Results from these experiments were used to develop and test a mathematical model describing tubificid sediment mixing as a dominantly advective process. Tubificids were found to mix sediments to a depth of 609 cm. The rate of tubificid sediment processing observed in the experiments agrees well with those reported by other workers. Extrapolation of laboratory results to Lake Erie shows that the feeding activity of tubificids alone may result in significant sediment mixing throughout the lake.

Frey, L. C., and E. F. Stoermer. 1980. Dinoflagellate Phagotrophy in the Upper Great Lakes. Trans. Am. Micros. Soc. 99(4): 439-444.

> Phagotrophy is observed commonly in some dinoflagellate populations which occur in the Laurentian Great Lakes. Ingested cells include representatives of all major phytoplankton groups common in the area, and occasional cells of benthic populations. There appears to be little selection on the basis of either cell type or size. The size of cells ingested ranges from small microflagellates to large centric diatoms approaching the volume of the dinoflagellate. No correlation between depth in the water column or light availability and the abundance of phagotrophic populations is apparent. Phagotrophic populations appear to be distributed uniformly in the water column to depths as great as 180 meters under both mixing and stratified lake conditions.

Fukuda, M. K., and W. Lick. 1980. The Entrainment of Cohesive Sediments in Freshwater. J. Geophys. Res. 85(C5): 2813-2824.

> Presented in this study are experimentally measured characteristics of the entrainment rate and settling speeds of fine-grained, cohesive sediments in freshwater. The investigation focused on three different sediments of varying mineral composition which are representative of the sediments of Lake Erie. The influences of the bulk sediment water content and of the mineral and size composition of the entrainment rate and equilibrium concentration of these suspended sediments were determined. Linear increases in the bulk sediment water content resulted in logarithmic increases in the entrainment rate and equilibrium concentration. For a limited range of shear stresses near that needed to initiate noticeable entrainment, the entrainment rate and equilibrium concentration increased logarithmically as the applied shear stress was increased linearly. For larger stresses, linear increases in the applied shear stress caused approximately linear increases in the entrainment rate and equilibrium concentration. At fixed values of water content and shear stress the entrainment rate and equilibrium concentration increased as the clay mineral content of the sediment increased and as the median particle size decreased. Settling speed experiments demonstrated that the median settling speed of the suspended sediment particles in a quiescent fluid increased as the ionic strength of the solution increased. At a fixed ionic strength the settling speed decreased with increased clay mineral content.

Glass, G. E. 1980. Susceptibility of Aquatic and Terrestrial Resources of Minnesota, Wisconsin, and Michigan to Impacts From Acid Precipitation: Informational Requirements. IN: Proceedings, International Conference on the Ecological Impact of Acid Precipitation, SNSF Project, pp. 112-113, Sandefjord, Norway.

> Surveys of lake water quality in northern Minnesota and Wisconsin reveal that approximately three-fourths of the lakes sampled are susceptible or potentially susceptible to acidification using the calcite saturation index as an approximate classification scheme. For some of the lakes in northern Wisconsin that fall above the upper curve, the threshold for acidification has already been exceeded. Historical data for 22 of the 127 Wisconsin lakes show large fluctuations of pH but as a group they show no obvious trend. For some of the low alkalinity lakes, the trend is in the direction of acidification; while for others, an increase in alkalinity appears to have occurred where there has been significant land use in the affected watershed. An in-depth comparative study of these historical data is needed. Limited data are available to determine the significance of the present atmospheric loadings of acids. Acid loadings by precipitation can be directly related to the resulting effects on lake pH as a dose-response relationship. Verification of these relationships and their application to individual watersheds is one of the most important research needs. The importance of measuring pollutant components lies in determiing whether or not the chemically

and biologically active forms and concentrations that make up the total dose are sufficiently comparable when interpreting cause-effect relationships. If comparable, the results pertaining to ecological responses observed in Scandinavia and elsewhere can be directly translated to predicting, understanding and controlling the developing ecological effects being observed in North America.

Hall, R. J., and G. E. Likens. 1980. Ecological Effects of Experimental Acidification on a Stream Ecosystem. IN: Proceedings, International Conference on the Ecological Impact of Acid Precipitation, SNSF Project, pp. 375-376, Sandefjord, Norway.

We report here the quantitative effects of experimentally increasing the acidity of a mountain stream ecosystem to pH levels frequently found in incident precipitation in the northeastern United States. Our field experiment was designed to test the hypothesis that such acidity of the streamwater would alter the biogeochemistry and the behavior and metabolism of microorganisms, periphyton, macroinvertebrates and fish. We conclude that the biotic structure, metabolism and biogeochemistry of a mountain stream ecosystem underlain by siliceous bedrock were quantitatively altered at pH levels commonly found during snowmelt and in ambient precipitation.

Hall, R. J., G. E. Likens, S. B. Fiance, and G. R. Hendrey. 1980. Experimental Acidification of a Stream in the Hubbard Brook Experimental Forest, New Hampshire. Ecology 61(4): 976-989.

Incident precipitation in the northeastern United States averages about pH 4 as a result of increased pollution from sulfuric and nitric acids. To determine the effect of this increased acidity on the ecology of aquatic ecosystems, dilute concentrations of sulfuric acid were added to Norris Brook, a stream in the Hubbard Brook Experimental Forest, West Thornton, New Hampshire, USA. The stream was maintained at pH 4 from April to September 1977.

With increased acidity stream water concentrations of Al, Ca, Mg, K, and probably Mn, Fe, and Cd were elevated; no change in dissolved organic carbon (DOC), Na, NO_3, NH_4, Ni, Pb, Cu, or Zn occurred at the lower pH. Emergence of adult mayflies (Ephemeroptera), some stoneflies (Plecoptera), and some true flies (Diptera) decreased at the lower pH. Larger numbers of immature aquatic invertebrates in the collector, scraper, and predator functional groups were found in drift samples from the experimental area during the 1st wk after acid addition. After the 1st wk of increased acidity total numbers of organisms drifting in the experimental area were similar to values obtained in the reference area. Emergence of adult collectors and invertebrate density in the benthos decreased in the treatment area. Periphyton biomass increased at the low pH, but hyphomycete fungal densities decreased. A basidiomycete fungus increased in the experimental area relative to the reference section. Brook trout showed no morphological signs of stress at the low pH. Stream acidification decreased species diversity, increased representation of community dominants, and decreased the complexity of the food web.

Hamilton, M. A. 1980. Inference about the ED50 using the Trimmed Spearman-Karber Procedure - A Monte Carlo Investigation. Commun. Statist.-Simula. Computa. B9(3): 235-254.

A Monte Carlo study was conducted to investigate the estimated standard errors of the estimate and the 95 percent confidence interval estimates associated with the trimmed Spearman-Karber (SK) estimators of the ED50 and the logistic model maximum likelihood estimator (MLE). The simulated binary response bioassay experiments had widely spaced doses with 5, 10, or 20 subjects per dose. For data following a logistic tolerance distribution, the trimmed SK confidence intervals were nearly as accurate as the logistic MLE intervals. For heavy-tailed tolerance distributions, the trimmed SK confidence intervals were more accurate than those based on the logistic MLE.

Hedtke, S. F., and F. A. Puglisi. 1980. Effects of Waste Oil on the Survival and Reproduction of the American Flagfish, *Jordanella floridae*. Can. J. Fish. Aquat. Sci. 37: 757-764. ERL-D Reprint #228.

Short-term lethality tests, tests on the 30-day survival of 1-day-old larvae, and a life cycle test showed that used crankcase oil adversely affected the survival and reproduction of the American flagfish, *Jordanella floridae*. Four-day LC50s for juveniles in static and flow-through tests were 36,200 µl/l and 9,500 µl/l, respectively, for the water-soluble fraction (wsf) of a 10% oil-water mixture and 485 µl/l and 82.7 µl/l, respectively, for oil-water emulsions. The general descriptive characteristics of the test oil and the hydrocarbon composition and concentration of 13 metals were determined for the oil and its water-soluble fraction. The life cycle test began with embryos and continued through 45 days of spawning. Egg production was impaired by exposure to 3,380 µl wsf/l. Tissue analyses indicated the uptake of lead, cadmium, and zinc at higher exposure levels. The 30-day LC50 for larvae exposed as embryos was 8,100 µl wsf/l and for larvae unexposed as embryos was 755 µl wsf/l. The maximum acceptable toxicant concentration for the water-soluble fraction of used crankcase oil was estimated to fall between 325 and 930 µl/l. Based on the compounds identified in the water-soluble fraction, previous toxicity data, and tissue residue analysis, we speculate that zinc, lead, and cadmium probably contribute significantly to the toxicity of the waste oil tested.

Holcombe, Gary W., James T. Fiandt, and Gary L. Phipps. 1980. Effects of pH Increases and Sodium Chloride Additions on the Acute Toxicity of 2,4-Dichlorophenol to the Fathead Minnow. Water Res. 14: 1073-1077. ERL-D Reprint #229.

> The observable toxic effects produced by short-term exposure of fathead minnows (Pimephales promelas) to 2,4-dichlorophenol, were reduced when the pH of the test water was increased by the addition of NaOH. After exposure for 192 h to 7.43 mg 2,4-dichlorophenol l^{-1}, the average survival of fathead minnows ranged from 28% at pH 7.57 to 100% at pH 9.08. Normal schooling behavior was completely disrupted, and the equilibrium of most fish was affected after a 24-h exposure to 7.43 mg 2,4-dichlorophenol l^{-1} at pH 7.57, but neither schooling nor equilibrium were affected even after 192 h at pH 8.68 and 9.08. Schooling and swimming behaviour of fathead minnows exposed to 12.33 mg 2,4-dichlorophenol l^{-1} were affected at all pH levels. Survival of these fish after 24 h ranged from 0% at pH 7.84 to 46% at pH 8.81. Sodium chloride in concentrations ranging from 0 to 13.9 mg l^{-1} had no observable effects on the acute toxicity of 2,4-dichlorophenol to fathead minnows.

Johnson, T. C. 1980. Late-Glacial and Postglacial Sedimentation in Lake Superior Based on Seismic-Reflection Profiles. Quat. Res. 13: 380-391.

> Seismic reflection profiles (3.5 kHz) were obtained along more than 3500 km of shiptrack in Lake Superior within the last 2 yr. The acoustic character of profiles is categorized as: (I) a single, strong reflector at the lake floor, (II) a thick, acoustically transparent layer overlying a strong reflector, and (III) relatively thick sediment with internal acoustic reflectors. These profiles, in conjunction with sediment cores from the area, reveal that varved glacial-lacustrine sediment settled out preferentially in a trough between Isle Royale and the north shore, and to a lesser extent in other topographic depressions; bottom currents generated by storm waves prevent clay accumulation on till or bedrock in the open lake wherever the bottom is shallower than 100 m; bottom currents prevent deposition or erode bottom sediment in certain deep-water (>200 m) valleys; and lacustrine sediment is disturbed by creep or slumping off Grand Portage, Minnesota; and by other processes such as dewatering in many other areas. These factors complicate sedimentation in Lake Superior, and must be considered when investigating any aspect of the lake sediment.

Johnson, T. C., T. W. Carlson, and J. E. Evans. 1980. Contourites in Lake Superior. Geology 8: 437-441.

> Contour currents influence sedimentation in an area 15 km wide and 65 km long at the base of the slope off the Keweenaw Peninsula in Lake Superior, northwestern Michigan. Seismic-reflection profiles (3.5 kHz)

from this area show distinct wavy reflectors in a scoured trough at a depth of 200 m at the base of the slope, hyperbolic echoes adjacent to the trough, and overlapping echos farther lakeward. These acoustic features are identical to those in marine environments where contourites are deposited. Box cores from the lakeward margin of this area contain what appeared to be contourites: irregular, thin sand layers with sharp upper and lower contacts, interbedded with sandy clay. The sandy clay layers are trough cross-laminated in some places and plain laminated in others. This is the first report of contourites in a lacustrine environment.

Jordan, T. F., and J. R. Baker. 1980. Vertical Structure and Time-Dependent Flow Dominated by Friction in a Well-Mixed Fluid. J. Physical Oceanogr. 10(7): 1091-1103.

Solutions of a linear hydrodynamic equation of motion with linear boundary conditions are obtained to describe the horizontal current, as a function of depth and time, determined by a given history of the wind force and pressure gradient up to that time, at a fixed point in the horizontal plane in well-mixed water of finite depth. The bottom friction is assumed to be proportional to the bottom current, with zero bottom current and zero bottom friction considered as limiting cases. The general solution is established as an eigenfunction expansion when the eddy viscosity is given as a positive function of depth. Eplicit formulas are worked out for viscosity functions that are constant, exponential, or varying as a power of the height from somewhere below the bottom or above the top of the water. For the latter the limit as the viscosity goes to zero at the bottom or top is considered. Numerical results are presented for viscosities that are constant, exponential, linear, or varying as the 3/4 power.

Kier, L. B. 1980. Use of Molecular Negentropy to Encode Structure Governing Biological Activity. J. Pharmaceutical Sciences 69(7): 807-810.

A drug molecule is considered to be an information source with an information content available to receptive tissue. In nonspecific interactions, much of the information content has quality as judged by the receptor. Quantitation of the information content using Shannon's equation gives the molecular negentropy. This index is shown to rank molecules according to symmetry and to encode structural characteristics influencing physical properties and biological activity in certain cases.

Korfmacher, W. A., D. F. S. Natusch, D. R. Taylor, G. Mamantov, and E. L. Wehry. 1980. Oxidative Transformations of Polycyclic Aromatic Hydrocarbons Adsorbed on Coal Fly Ash. Science 207: 763-765.

Polycyclic aromatic hydrocarbons adsorbed onto coal fly ash were found to be stabilized against photochemical decomposition. However, a number of adsorbed polycyclic aromatic hydrocarbons will spontaneously oxidize in the absence of light, with those compounds containing a benzylic carbon being particularly susceptible. The decomposition rate appears to be fly ash-dependent.

Korfmacher, W. A., E. L. Wehry, G. Mamantov, and D. F. S. Natusch. 1980. Resistance to Photochemical Decomposition of Polycyclic Aromatic Hydrocarbons Vapor-Adsorbed on Coal Fly Ash. Environ. Sci. Technol. 14(9): 1094-1099.

Five polycyclic aromatic hydrocarbons (benzo[a]pyrene, pyrene, anthracene, fluoranthene, and phenanthrene) have been adsorbed, from the vapor phase, onto coal fly ash, and the susceptibility of each of the adsorbed compounds to photodecomposition has been studied. Benzo[a]pyrene, pyrene, and anthracene all photolyze efficiently in liquid solution but are highly resistant to photodegradation when adsorbed on fly ash. However, benzo[a]pyrene and anthracene photolyze with high efficiency when adsorbed on activated alumina. Thus, the photosensitivity of an adsorbed polynuclear hydrocarbon is strongly dependent upon the nature of the surface upon which the compound is adsorbed. Phenanthrene and fluoranthene are resistant to photodecomposition both in liquid solution and as adsorbates on fly ash. The environmental consequences of the resistance of polycyclic aromatic hydrocarbons adsorbed on fly ash to photochemical transformation are discussed.

Kuehl, D. W., and R. C. Dougherty. 1980. Pentachlorophenol in the Environment. Evidence for its Origin from Commercial Pentachlorophenol by Negative Chemical Ionization Mass Spectrometry. Environ. Sci. Technol. 14: 447-449. ERL-D Reprint #223.

Commercial pentachlorophenol (PCP) contains significant quantities of tetrachlorophenol (TCP). The occurrence of TCP in environmental samples provides a chemical marker for PCP originating from commercial formulations. Negative chemical ionization mass spectrometry has been used to examine a commercial PCP formulation and a series of environmental and human samples. Tetrachlorophenol was determined by the ion current at m/z 229, tetrachlorophenoxide, and PCP was determined by the ion current at m/z 267, pentachlorophenoxide. The ion current at m/z 267 may include contributions from the oxygen/chloride exchange product of hexachlorobenzene, an environmental precursor of PCP. The ratio of PCP to TCP in Dowcide G-ST, a commercial PCP formulation, was 2.5 ± 0.1. The ratio of m/z 267 to m/z 229 in a jellyfish, *Mnemiopsis macrydi*, from the Gulf of Mexico was 2.7 ± 0.1, in human semen it was 4.1 ± 0.1, and in human adipose tissue it was 15.5 ± 0.1. PCP in the semen samples was concentrated in the sperm cells by a factor of 9.

Kuehl, D. W., and R. C. Dougherty. 1980. Screening of Human and Food Chain Samples for Contamination with Toxic Substances Using Negative Chemical Ionization Mass Spectrometry. IN: Advances in Mass Spectrometry, Vol. 8B, (A. Quayle, ed.), pp. 1451-1459, Heydon and Son, Ltd., London. ERL-D Reprint #237.

> Negative chemical ionization mass spectrometry, micro-scale continuous liquid-liquid extraction steam distillation, and micro-scale gel permeation chromatography techniques have been developed for screening of biological samples for hazardous synthetic organic chemicals. The methodology was successfully used to identify unusual chemicals such as octachlorostyrene and polychlorinated dibenzofurans in fish as well as many pesticides and polychlorinated biphenyls in human semen.

Kuehl, D. W., R. C. Dougherty, Y. Tondeur, D. L. Stalling, L. M. Smith, and C. Rappe. 1980. Negative Chemical Ionization Studies of Polychlorinated Dibenzo-p-dioxins, Dibenzofurans, and Naphthalenes in Environmental Samples. IN: Environmental Health Chemistry, The Chemistry of Environmental Agents as Potential Human Hazards, Chapter 12, (J. D. McKinney, ed.), pp. 245-261, Ann Arbor Science Publishers, Inc. ERL-D Reprint #236.

> Gel permeation chromatography, carbon coated polyurethane foam chromatography and negative chemical ionization mass spectrometry have been used for the selective and sensitive analyses of planar polychlorinated molecules, including naphthalenes, dibenzofurans, and dibenzo-p-dioxins, in fish from 13 sites in the U.S., sediment from Waukegan Harbor on Lake Michigan and a seal from the Baltic Sea. Chlorinated naphthalenes were found in all but the seal sample, chlorinated dibenzofurans were found in 8 of the samples and chlorinated dibenzo-p-dioxins were found in only two samples.

Kuehl, D. W., E. N. Leonard, K. J. Welch, and G. D. Veith. 1980. Identification of Hazardous Organic Chemicals in Fish from the Ashtabula River, Ohio, and Wabash River, Indiana. J. Assoc. Off. Anal. Chem. 63(6): 1238-1244. ERL-D Reprint #234.

> Complete fish samples from the Wabash River, Indiana, and the Ashtabula River, Ohio, were analyzed by conventional pesticide procedures for PCBs, DDTs, chlordane components, and hexachlorobenzene. Additional aliquots of each sample were processed by gel permeation chromatography and were analyzed with gas chromatography-mass spectometry by using both electron impact and negative chemical ionization modes. These anlyses resulted in the identification of a series of chlorinated alkanes, chlorinated alkenes, chlorinated alkylamines containing 2-5 carbons, and polychlorinated styrenes in the Ashtabula River sample, and a series of chlorinated norbornenes, pentachlorobenzyl alcohol, and pentachlorophenol in the Wabash River sample.

Kuehl, D. W., M. J. Whitaker, and R. C. Dougherty. 1980. Micromethods for Toxic Residue Screening by Negative Chemical Ionization Mass Spectrometry. Anal. Chem. 52: 935-940. ERL-D Reprint #222.

Methods were developed for the analysis of polychlorinated chemical residues found in milligram quantities of biological samples. Sample preparation by micro continuous liquid-liquid extraction steam distillation or by micro gel-permeation chromatography gave sufficiently clean residue extracts for negative chemical ionization analysis. With these techniques, chemical such as chlorophenols and chlorobiphenyls have been confirmed in human adipose samples as small as 12.5 mg. These methods make it possible to screen <1-g samples of biological substrates for contamination with persistent toxic substances at part-per-billion levels.

Lee, G. F., R. A. Jones, and W. Rast. 1980. Availability of Phosphorus to Phytoplankton and its Implications for Phosphorus Management Strategies. IN: Phosphorus Management Strategies for Lakes, Chapter 11, pp. 259-308, Ann Arbor Science, Ann Arbor, Michigan.

One of the questions associated with the development of a cost-effective phosphorus management strategy for a waterbody concerns whether the control program should be based on total phosphorus or on algal available phosphorus entering the waterbody. Until now, eutrophication control programs have been based largely on the control of any form of phosphorus that was amenable to control, irrespective of whether the phosphorus was in a form which could support algal growth.

This paper reviews the current state of information on the algal availability of phosphorus from major sources contributing P to the Great Lakes, methods for assessing the algal availability of phosphorus and the importance of developing phosphorus management strategies based on algal-available phosphorus rather than on total phosphorus. Although the focal point of the paper is the Great Lakes, the results are equally applicable to waterbodies throughout the world.

Lind, A. E., and G. E. Glass. 1980. Asbestos Contamination of Lake Superior: Ten Years of Litigation - U.S.A. vs. Reserve Mining Company. IN: Contaminants and Sediments - Fate and Transport, Case Studies, Modeling, Toxicity, Volume 1 (R. A. Baker, ed.), pp. 219-270, Ann Arbor Science, Ann Arbor, Michigan.

Studies focusing on the impacts of the largest industrial discharge in the U.S. (Reserve Mining Company, Silver Bay, Minnesota) to the largest freshwater lake, Lake Superior, have been subjected to intensive scientific and legal scrutiny from 1969 - 1978. The period of greatest activity was during the 139 day Federal District Court trial in which over 100 witnesses presented testimony and 1,621 exhibits, and generated

18,000 pages of transcript. The issues ranged from eutrophication of the lake to asbestos caused cancer. The Court has ordered the Company to pay fines of $1,200,000, use on-land disposal of tailings by 1980, and to provide filtered water for municipalities using Lake Superior water. A discussion and summary of the findings of fact, technical studies, and current disposition of the case will be presented.

Matusiewicz, H., and D. F. S. Natusch. 1980. Ion Chromatographic Determination of Soluble Anions Present in Coal Fly Ash Leachates. Intern. J. Environ. Anal. Chem. 8: 227-233.

> The advent of ion chromatography has provided an extremely useful tool for the rapid, precise and sensitive determination of inorganic anions. This capability can be put to excellent use in the determination of soluble anions associated with coal fly ash. Methodology applicable to determination of F^-, Cl^-, CO_3^{2-}, NO_3^-, and SO_4^{2-} is described. Both the element solution concentration and pump pressures were varied to achieve optimal conditions in terms of resolution and speed of analysis. The precision of this method of analysis was determined to be ±3% and the accuracy ±5%. Replicate analysis of these coal fly ash leachate samples varied by less than 3%. In all cases % relative standard deviations were better than 3%.

McCormick, J. H., G. N. Stokes, and G. J. Portele. 1980. Environmental Acidification Impact Detection by Examination of Mature Fish Ovaries. Can. Tech. Rep. Fish. Aquat. Sci. 975: 41-48. ERL-D Reprint #241.

> Fathead minnow egg production and hatching success at pH 5.3 was scant to non-existent. Eggs spawned and incubated until hatching at pH 8.1 and 6.3 produced 39.7 and 5.7% normal larvae, respectively; eggs spawned at pH 6.3 incubated at 5.3 produced 0.5% normal larvae. Reproductive failure at pH 5.3 may have been predicted by ovarian histology. Ovaries of fathead minnows at pH 5.3 had exceptionally high proportions of pre-ovulatory corpora atretica relative to other oocyte stages present. The fathead minnow data were generated as a basis of extrapolation to estimate reproductive impairment in smallmouth bass inhabiting acid environments by examination of their ovarian condition.

McNaught, D. C., D. Griesmer, and M. Kennedy. 1980. Resource Characteristics Modifying Selective Grazing by Copepods. IN: Evolution and Ecology of Zooplankton Communities (W. C. Kerfoot, ed.), pp. 292-298, University Press of New England.

> Algal resource characteristics, including the size, shape, and presence of a sheath, were examined for their modifying influence on selective grazing. Three green and two blue-green algae were grown in culture and

fed in pairs to the crustacean plankton that occurred in Lake Huron in spring; animals were preconditioned before testing. Only two of seven forms were selective specialists, including adult Diaptomus sicilis and immature cyclopoid copepods. Three species of adult cyclopoids and one cladoceran were generalists in feeding. The selective grazers chose large and small plain cells over sheathed and spined algae. Certainly the presence of a sheath was overwhelmingly important in modifying resource utilization; sheathed algae exhibit increased fitness, as evidenced by their success in forming blooms.

Melancon, M. J., and J.J. Lech. 1980. Uptake, Metabolism, and Elimination of ^{14}C-Labeled 1,2,4-Trichlorobenzene in Rainbow Trout and Carp. J. Toxicol. Environ. Health 6: 645-658.

Fingerling rainbow trout (Salmo gairdneri) were exposed to ^{14}C-labeled 1,2,4-trichlorobenzene (TCB) for 8 h in a static exposure (0.018 mg/l) or for 35 d in a continuous-flow exposure (0.020 mg/l) followed by a subsequent elimination period. For the 2 d after the 8-h exposure, the half-time ($t_{1/2}$) of elimination of ^{14}C from muscle and liver was 0.4 d, while after the 35-d exposure an early rapid elimination of ^{14}C from these tissues ($t_{1/2} = 0.4$ d) was followed by a slower elimination ($t_{1/2} = 50$ d) during d 4-36. The maximum bioconcentration factors for ^{14}C in muscle and liver were 51 and 102 after the 8-h exposure and 89 and 389 during the 35-d exposure. The values for bile were much greater, reaching 240 after the 8-h exposure and 1400 during the 35-d exposure. When larger trout and carp (Cyrpinus carpio) were exposed to [^{14}C]TCB (0.2-0.4 mg/l) the bioconcentration factor for bile ^{14}C to water ^{14}C was less than 100. Pretreatment of trout with β-naphthoflavone, an inducer of hepatic mixed-function oxidase, increased this bioconcentration factor for bile to several hundred. Solvent partitioning and thin-layer chromatography (TLC) indicated that about 60% of the ^{14}C in bile of control trout or carp was present as highly polar biotransformation products, while for induced trout the value was more than 90%. TLC in two solvent systems suggested that at least two such products were present in bile from control fish and at least three in bile from induced fish. About half of the ^{14}C in bile from induced trout was more polar than the ^{14}C in bile from normal trout.

Meyers, P. A., N. Takeuchi, and J. A. Robbins. 1980. Petroleum Hydrocarbons in Sediments of Saginaw Bay, Lake Huron. J. Great Lakes Res. 6(4): 315-320.

The history of petroleum contamination of Saginaw Bay is given by a 60 cm core recording sediment accumulation over the last two centuries. Aliphatic hydrocarbon concentrations average 385 μgm/gm in modern sediments and progressively decrease from 10 cm to 40 cm in the core to average 30 μgm/gm in sediments deposited before 1876. An unresolved complex mixture of hydrocarbons diagnostic of petroleum represents about

90 percent of the total concentration in all core sections deposited over the last 100 years. In older sediment, this decreases but still comprises 40 percent of the total at the bottom of the core. These patterns indicate a large input of nonbiogenic hydrocarbons which has accumulated in the sediments of Saginaw Bay. While a portion of these may originate from natural sources, such as forest fires and erosion of ancient sediments, we conservatively estimate that 2 to 4 x 10^4 Tonne of petroleum hydrocarbons have been introduced to Saginaw Bay since the 1870s.

Moll, R. A., C. O. Davis, and C. L. Schelske. 1980. Phytoplankton Productivity and Standing Crop in the Vicinity of the Lake Huron-Saginaw Bay Front. J. Great Lakes Res. 6(3): 232-246.

Continuous underway sampling was used in four research cruises near the mouth of Saginaw Bay in order to locate the bay-lake front, where eutrophic bay water mixes with oligotrophic Lake Huron water. Although mixing between these water masses normally occurs in outer Saginaw Bay, the distribution was variable, depending on wind force and direction as well as water temperature. Large algal crops in inner Saginaw Bay had reduced soluble nutrients, particularly silicate and nitrate-nitrogen, in the outer bay to levels lower than the adjacent lake water. Nonetheless, outer bay water supported high algal biomass (up to 14 μg/l chlorophyll a) and ^{14}C uptake (up to 73 μg/l/h). The phytoplankton community at the nutrient front between bay and lake waters was characterized by high chlorophyll a biomass ($x = 4.47$ μg/l), low ^{14}C uptake ($x = 7.12$ μg/l/h), and high bacterial activity (V_{max} $x = 1.33$) indicating the presence of a senescent assemblage. Decomposition and settling of phytoplankton in the vicinity of the front apparently served to remove much of the bay plankton from the water column before mixing into the open lake. But, during mid-summer, occassional large inputs of nutrients and/or phytoplankton from the bay into the open lake were observed.

Mount, D. I. 1980. Needs of Toxicity Tests to Meet Specific Regulations. IN: Biological Monitoring of Fish, (C. H. Hocutt, and J. R. Stauffer, Jr., eds.), pp. 33-41, Lexington Books, D. C. Heath and Co., Lexington, Massachusetts.

Toxicity tests performed to meet regulatory needs, must be designed to answer the precise requirements and usually will follow somewhat different protocols than tests done for research purposes. Many scientists are critical of such tests because they are not aware of the restrictions that must be met in such tests. Instead they substitute their own biases, objectives and ideals for those laid down in the governing regulations. Economics play a deciding role in the test protocols that are acceptable for practical use and time frames often prohibit the use of many tests.

Munson, B. H., J. H. McCormick, and H. L. Collins. 1980. Influence of Thermal Challenge on Conditioned Feeding Forays of Juvenile Rainbow Trout. Trans. Am. Fish. Soc. 109: 116-121. ERL-D Reprint #219.

Juvenile rainbow trout (Salmo gairdneri) conditioned to traverse a 2.4-m-long channel to receive a food reward were subjected to in-transit thermal challenges. Conditioning was to a criterion that required 80% of the fish to leave the "home" area and reach the "reward" area within 2 minutes of release. Challenges were at successive 3 C increments above acclimation or the previous challenge temperature. Fish were first observed to delay their entrance into the intervening heated water at challenge temperatures of 12-15 C above acclimation. At each increment above 12-15 C over acclimation temperature, delay in transit increased; however, complete group inhibition was never achieved. Above their critical thermal maximum (CTM) the reward was achieved even at the expense of deaths among the achievers. Responses were the same whether fish were challenged individually or as groups. Fish exposed to their CTM without prior challenges at less stressful temperatures responded similarly to those receiving progressively greater challenges.

Natusch, D. F. S. 1980. Recent Advances in Surface Analysis of Environmental Particles. IN: Analytical Techniques in Environmental Chemistry (J. Albaiges, ed.), pp. 501-514, Pergamon Press, Oxford and New York.

The use of electron microprobe X-ray spectrometry, electron spectroscopy for chemical analysis, Auger electron spectrometry, and secondary ion mass spectrometry for performing surface analyses is described. Several examples of applications of these techniques to surface studies of environmental and source particulates are presented. It is apparent that many potentially undesirable species are enriched at the surfaces of anthropogenic particles and that most of these species are readily soluble in aqueous solution even though the bulk particulate material is essentially insoluble. It is concluded that surface analysis can provide valuable insights into the processes of formation and transformation of environmental particles and into their potential environmental impact.

Natusch, D. F. S., E. R. Denoyer, T. R. Keyser, S. E. Kirton, D. R. Taylor, and M. V. Zeller. 1980. Surface Analysis of Particles Emitted to the Atmosphere. Am. Instit. Chem. Engin. 76(201): 127-133.

A number of potentially toxic trace metal and organic species have been shown to be preferentially enriched on the surfaces of most types of anthropogenic particles which are emitted to the atmosphere. The use of several surface analytical techniques including ion microprobe mass spectrometry, Auger electron spectrometry, electron spectrometry for chemical analysis (ESCA), and time resolved solvent leaching for the study of such particles is discussed. Results are evaluated in terms of the information they provide about the processes of particle formation and transformation and about potential environmental impacts. In addition, the strengths and weaknesses of the different techniques are compared with emphasis on those directly related to particle surface analysis.

Olson, D. L., and G. M. Christensen. 1980. Effects of Water Pollutants and Other Chemicals on Fish Acetylcholinesterase (in vitro). Environ. Res. 21: 327-335. ERL-D Reprint #221.

Acetylcholinesterase (AChE) preparations from the muscle of the fathead minnow (Pimephales promelas Rafinesque) were treated (in vitro) with 74 chemicals of various classes, many of which are environmental contaminants, to determine their effect upon enzyme activity. A highly inhibitory effect was found with several carbamates, one organo-oxyphosphate, the arsenite ion, and certain heavy metal cations. Intermediate inhibition was found with the arsenate ion, other metal cations, organometals, certain neuroactive agents, organophosphates, and one organochloride pesticide. Several organochloride pesticides, alkaline and alkaline-earth cations, a variety of anions, several drugs, and other chemicals had little inhibitory effect at the highest concentration used (0.01 M). The effect of chemicals in mixtures of known composition was approximately additive. None of the chemicals tested caused detectable enzyme activation.

Parkinson, A., L. Robertson, L. Safe, and S. Safe. 1980. Polychlorinated Biphenyls as Inducers of Hepatic Microsomal Enzymes: Structure-Activity Rules. Chem.-Biol. Interact. 30: 271-285.

A number of highly purified polychlorinated biphenyl (PCB) isomers and congeners were synthesized and administered to male Wistar rats at dosage levels of 30 and 150 μmol $\cdot$ kg^{-1}. The effects of this in vivo treatment on the drug-metabolizing enzymes were determined by measuring the microsomal benzo[a]pyrene (B[a]P) hydroxylase, dimethylaminoantipyrine (DMAP) N-demethylase and NADPH-cytochrome c reductase enzyme activities, the cytochrome b_5 content and the relative peak intensities of spectral shifts of the reduced microsomal cytochrome P-450 : CO and ethylisocyanide (EIC) binding difference spectra. The results were compared to the effects of administering phenobarbitone (PB), 3-methylcholanthrene (MC) and PB plus MC (coadministered) to the test animals. The synthetic PCB congeners used in this study included 3,4,4',5-tetrachlorobiphenyl (TCBP-1), 2,3',4,4'-tetrachlorobiphenyl (TCBP-2), 2,3'4,4',5'-pentachlorobiphenyl (PCBP-1), 2,3,4,4',5-pentachlorobiphenyl (PCBP-2), 2,3,3',4,4',5-hexachlorobiphenyl (HCBP-1), 2,3,3',4',5,6-hexachlorobiphenyl (HCBP-2), 2,3,3',5,5',6-hexachlorobiphenyl (HCBP-3), 2,2',3,5,5',6-hexachlorobiphenyl (HCBP-4) and 2,3,3',4,5,5'-hexachlorobiphenyl (HCBP-5) and were used to reappraise the structure-activity rules for PCBs as hepatic microsomal enzyme inducers. The results suggested that (a) PCBs which induce MC or mixed-type activity must be substituted at both para positions, at least two meta positions but not necessarily on the same phenyl ring and can also contain one ortho chloro substituent; (b) due to the considerable structural diversity of the PB-type inducers the rules for induction of this activity by PCB congeners are not readily defined.

Pfeifer, K. F., and L. J. Weber. 1980. The Effect of Carbon Tetrachloride Treatment on Urine Flow Rate of the Rainbow Trout, Salmo gairdneri. Toxicol. Appl. Pharmacol. 52: 347-350.

> Urine flow rate (UFR) of rainbow trout was measured as an assessment of water balance after treatment with a single ip dose of CCl_4 (2.0 ml/kg). CCl_4 produced an oliguria or anuria as early as 1 hr post-treatment and a significant reduction in the 24-hr urine output. UFR for control fish appeared to follow a diurnal pattern. Additionally, CCl_4-treated fish had a significant increase in relative wet body weight that was negatively correlated to UFR. The rainbow trout normally excretes a hypoosmotic urine; therefore, an increase in urine osmolality and a slight proteinuria further suggested that treated fish had suffered an alteration in renal homeostasis. Histological examination of kidney tissue at 24 hr post-treatment revealed early, localized pathological changes; however, extensive morphological damage was absent. The early oliguria and the lack of demonstrable renal histopathological changes in CCl_4-treated rainbow trout suggest that the reduction in UFR was not the result of a direct toxic effect on the kidney.

Pfeifer, K. F., L. J. Weber, and R. E. Larson. 1980. Carbon Tetrachloride-Induced Hepatotoxic Response in Rainbow trout, Salmo gairdneri, as Influenced by Two Commercial Fish Diets. Comp. Biochem. Physiol. 67C: 91-96.

1. Alanine aminotransferase (GPT) activity was measured in plasma and liver from rainbow trout fed two commercial fish diets.
2. Plasma enzyme activities for the two groups of fish were significantly different at 3, 6, 12 and 18 hr after treatment with CCl_4 at 1.0 ml/kg.
3. No correlation was found between the degree of hepatocellular damage and elevated plasma GPT activity or the diet.
4. Central vein necrosis was not evident in either dietary group of CCl_4-treated trout.
5. Dietary constituents and contaminants are discussed as potential variables in this study.

Pickering, Q. H. 1980. Chronic Toxicity of Hexavalent Chromium to the Fathead Minnow (Pimephales promelas). Arch. Environ. Contam. Toxicol. 9: 405-413. ERL-D Reprint #231.

The chronic effects of hexavalent chromium on the fathead minnow (Pimephales promelas) were investigated. Survival was affected only at the high test concentration of 3.95 mg Cr/l. All chromium concentrations, including 0.018 mg/l, the lowest tested, retarded the early growth of first-generation fish, but this effect was only temporary. Growth of second-generation fish was not affected at concentrations of 1.0 mg/l or lower. Reproduction and hatchability of eggs were not affected at any chromium concentration tested.

The maximum acceptable toxicant concentration (MATC) for fathead minnows in hard water (209 mg/l as $CaCO_3$ at pH 7.7) was based on survival and lies between 1.0 and 3.95 mg Cr/l, respectively. The application factor (MATC/96-hr LC50) is between 0.03 and 0.11.

Poldoski, J. E. 1980. Determination of Lead and Cadmium in Fish and Clam Tissue by Atomic Absorption Spectrometry with a Molybdenum and Lanthanum Treated Pyrolytic Graphite Atomizer. Anal. Chem. 52(7): 1147-1151. ERL-D Reprint #226.

A molybdenum and lanthanum treated pyrolytically coated graphite tube is employed for the furnace atomic absorption spectrometric determination of lead and cadmium directly in nitric-perchloric acid tissue digests. Lanthanum tends to promote the formation of a smooth lead atomization peak for aid in peak quantitation. Both molybdenum and lanthanum help reduce chemical interference and interference from uncompensated background signals during analyte atomization. Under typical conditions, the average analytical recoveries are within the 90-110% range for both lead and cadmium, and peak height reproducibility is about 2-3% when working sufficiently above detection limits. Accuracy of the method is assessed by analyzing the NBS SRM 1577 bovine liver standard and performing alternate determinations by anodic stripping voltammetry.

Rhee, G.-Y. 1980. Continuous Culture in Phytoplankton Ecology. IN: Advances in Aquatic Microbiology, Vol. 2 (M. R. Droop and H. W. Jannasch, eds.), pp. 151-203, Academic Press, London and New York.

Temporal variation in diel periodicity in growth, nutrient absorption and physiological processes may be an important ecological strategy for the survival and coexistence of various phytoplankters. This can best be evaluated using continuous cultures.

New potential applications of continuous culture methods in investigating natural populations have been demonstrated by the work of Barlow and his co-workers. These studies may serve as a good example of how one can bridge the gap between laboratory work and field investigations. The field continuous culture apparatus designed by de Noyelles and O'Brien may also prove to be valuable in studying natural populations in situ.

Rhee, G.-Y., and I. J. Gotham. 1980. Optimum N:P Ratios and Coexistence of Planktonic Algae. J. Phycol. 16: 486-489.

The optimum atomic ratio of N to P, the ratio at which one nutrient limitation changes over the other, was determined in seven species of freshwater planktonic algae. The ratio varied over a wide range among species; the average for these species was 17. If the cellular nutrient ratios in marine species are comparable with those in freshwater organisms, Redfield's ratio of 15 is remarkably close to the average. Cellular N:P ratios varied over a 24-h period under a light:dark cycle. The variation of the optimum ratio between species and diel change in cellular N:P ratios within a species could play an important role in population dynamics by enhancing the probability of coexistence of species.

Rodgers, P. W., and J. V. DePinto. 1980. Algae-Bacteria Interaction in a Light-Dark Cycle. J. Freshwater Ecol. 1(1): 71-80.

Nutrient and population dynamics accompanying algae-bacteria interaction were observed in unialgal, 18-liter batch cultures during a light-dark cycle. The green alga *Chlorella vulgaris*, and the nitrogen fixing blue-green *Anabaena flos-aquae* were inoculated with an aquatic community of bacteria. The bacteria community enhanced the regeneration of nutrients. Of special note, is the observed generation of soluble nitrogen in the synthetic growth media via nitrogen fixation followed by mineralization.

Schelske, C. L. 1980. Dynamics of Nutrient Enrichment in Large Lakes: The Lake Michigan Case. IN: Restoration of Lakes and Inland Waters, International Symposium on Inland Waters and Lake Restoration, Portland, Maine.

Lake Michigan is an interesting case to consider in discussing the dynamics of eutrophication. Although many environmental changes indicate that accelerated eutrophication has occurred, the main body of the lake is primarily mesotrophic. For example, open lake chlorophyll *a* concentrations do not exceed 3 to 4 μg/l during the spring bloom and concentrations of a lake-wide basis average 8 μg P/l. Results of nutrient enrichment experiments with natural phytoplankton assemblages show that phytoplankton growth can be increased with small phosphorus additions and that effects of phosphorus are greater when water is enriched simultaneously with phosphorus and trace constituents (EDTA, trace metals, and vitamins). Effects of eutrophication are manifested to the greatest extent in nearshore areas where, if localized nutrient sources are adequate, phytoplankton standing crops may be many times greater than in the offshore waters. Data on nutrient inputs show that the effects should be localized because inputs are not uniform over the lake basin.

Schnoor, J. L., and D. M. DiToro. 1980. Differential Phytoplankton Sinking- and Growth-Rates: An Eigenvalue Analysis. Ecol. Model. 9: 233-245.

An eigenvalue analysis of the vertical phytoplankton biomass equation is applied to calculate the differential sinking- and loss-rates of phytoplankton for different taxonomic groups in Lake Lyndon B. Johnson (LBJ) (Texas) and in Lake Erie. The analysis includes factors determining the phytoplankton composition, including losses due to turbulent mixing and to sinking, and a death-term to account for endogenous decay and predation. Gross growth-rates were obtained from community and individual ^{14}C production data (autoradiography) and from biomass measurements. Green algae produced the largest gross growth-rates, 1-1.75 d^{-1}, and the largest calculated sinking-rates, 1-3 m d^{-1}. The lowest gross growth-rates (<0.5 d^{-1}) and sinking-rates (<0.1 m d^{-1}) were determined for blue-green algae and phytoflagellates, while diatoms were intermediate, with growth-rates generally in the range 0.25-0.75 d^{-1} and calculated sinking-rates of 0.1-1.0 m d^{-1}.

Skogerboe, R. K., M. M. Miller, D. L. Dick, R. V. Thurston, and R. C. Russo. 1980. The Water Quality of Rosebud Creek, Montana, 1975-1977: Compilation of Chemical Data. NREL-FBI (Natural Resource Ecology Laboratory - Fisheries Bioassay Laboratory) Technical Report No. 4. 116 pp.

The results of an 18-month study of the water quality characteristics of Rosebud Creek, Montana, are summarized in this report. The sample collections cover the period from October 1975 through April 1977. The sampling stations range from the headwaters region of Rosebud Creek to immediately above its confluence with the Yellowstone River. The most intensive sampling occurred near where Cow Creek enters Rosebud Creek. This includes the region most likely to be affected by coal mine drainage and/or contaminants emitted to the atmosphere by the coal-fired power plant located at Colstrip.

The data listed in this report were collected at part of a larger study on Rosebud Creek which included determination of the distribution of fishes and aquatic macroinvertebrates. The present compilation of water chemistry data is presented so it may be available for inspection and use by other investigators and agencies. A report delineating the conclusions to be drawn from these data is in preparation.

Sonzogni, W. C., and W. R. Swain. 1980. Perspectives on U.S. Great Lakes Chemical Toxic Substances Research. J. Great Lakes Res. 6(4): 265-274.

> Because of their magnitude, their geographic and demographic characteristics, and their unique limnological properties, the Great Lakes appear to be especially susceptible to chemical contamination. The scientific basis for dealing with this contamination is very limited compared with the magnitude of the problem. This is particularly evident when the vast array of toxic xenobiotic substances of anthropogenic origin are considered. Major knowledge gaps exist on the critical transport pathways, ultimate fate, and ecological effects of toxic substances (of urgent importance are health effects on humans residing in the basin), as well as on the economic and social aspects of toxics management.
>
> The economic climate of the 1980s, however, is likely to severely limit the resources available for conducting research which is so badly needed. Consequently, it appears that the Great Lakes research community will have imposed upon it a markedly increased demand for information and a concomitant reduction in the resources available to accomplish the task. Finally, despite a pessimistic outlook for research support, there is optimism that the Great Lakes will respond positively, and in a relatively short time span (years as opposed to centuries), to the abatement of toxic inputs. Nevertheless, additional information on the processes affecting the distribution and fate of toxic substances is still critical to the understanding required to ensure effective remedial actions.

Spehar, R. L., R. W. Carlson, A. E. Lemke, D. I. Mount, Q. H. Pickering, and V. M. Snarski. 1980. Effects of Pollution on Freshwater Fish. J. Water Pollut. Control Fed. 52(6): 1703-1768. ERL-D Reprint #230.

> A review of the 1980 world literature was conducted on the effects of pollution on freshwater fish. This review contained 401 references and included papers on water quality such as dissolved gases and pH; chemical pollutants such as insecticides, herbicides, piscicides and anesthetics; inorganics, organics and industrial and municipal effluents including chlorine and wastewater and pulp and paper. Papers from reviews and symposia and those dealing with physical factors were also included. Within the above sections, papers were organized into general articles, surveys, toxicology, bioaccumulation, physiology and behavior.

Spehar, R. L., J. T. Fiandt, R. L. Anderson, and D. L. DeFoe. 1980. Comparative Toxicity of Arsenic Compounds and Their Accumulation in Invertebrates and Fish. Arch. Environ. Contam. Toxicol. 9: 53-63. ERL-D Reprint #217.

The toxicity of arsenic III, arsenic V, sodium dimethyl arsenate, and disodium methyl arsenate to stoneflies, snails, amphipods, and trout, and the bioaccumulation of these compounds were studied during a 28-day flow-through test. Daphnia magna were exposed for 21 days in static tests to determine life-cycle effects. All animals were exposed to concentrations of approximately 100 and 1000 μg/l (as arsenic) of each of the compounds. Arsenic III, the most toxic compound, caused a significant reduction in the survival of amphipods at 1000 μg As/l after seven days. None of the compounds significantly affected the survival of other test species after 28 days or reduced young production in Daphnia after 14 days of exposure. The concentration of accumulated arsenic in stoneflies, snails, and Daphnia was as much as 131, 99, and 219 times greater than the water concentration, whereas amphipods and rainbow trout contained arsenic residues similar to the controls. Residues in stoneflies, snails, and Daphnia exposed to 1000 μg As/l were higher than those in animals exposed to 100 μg As/l, but appeared to reach a steady state after 14 days. Total arsenic accumulation was greatest in organisms exposed to inorganic arsenic, particularly at 100 μg/l.

Stortz, K. R., and M. Sydor. 1980. Transports in the Duluth-Superior Harbor. J. Great Lakes Res. 6(3): 223-231.

A hydrodynamic model and a water quality model for the Duluth-Superior harbor are developed and verified by using data on currents, water levels, and water quality parameters. The water quality model is subsequently used to simulate the transport of particulates resuspended by ship traffic and the dispersal of dissolved material spilled into the harbor at a major industrial site.

Resuspension of bottom sediments by ship traffic is an important secondary source of harbor turbidity. Suspended solids in ship resuspension plumes range from 10 to 50 mg/l, five times the usual concentration of suspended solids in the harbor. An estimated 10^5 kg of material is resuspended per passage of a ship. The resuspended material is coarse and settles rapidly, thus only 0.1% of the material flows out directly into Lake Superior. Most of the material resuspended by ship traffic is redistributed to the low turbulence areas within the shipping channels.

It was found that a spill of dissolved pollutants in the inner harbor would take from 8 to 21 days to reach Lake Superior at peak concentrations. The peak concentration of pollutant at the lake entries depends on seiche amplitude and ranges from 0.05 to 0.1% of the initial concentration at the spill site. At a 0.1% concentration level, the spill would extend over 30% of the harbor, and would remain in the harbor for 30 to 40 days.

Sun, M. S., D. K. Harriss, and V. R. Magnuson. 1980. Activity Corrections for Ionic Equilibria in Aqueous Solutions. Can. J. Chem. 58(12): 1253-1257.

Activity corrections for ionic equilibria in aqueous solutions at 25°C and ionic strengths up to 0.5 have been investigated. An empirical formula for activity corrections was generated by statistically fitting stability constant data for approximately 540 complexes, for which both thermodynamic and concentration stability constants were known, to a modified Debye-Huckel relationship. The general formula is

$$\Delta \log K = 0.51[\sqrt{I}/(1 + 1.51\sqrt{I}) - 0.08]X - 0.09I$$

$X>0$, where $\Delta \log K$ is the difference in the logarithms of the stability constants at infinite dilution and finite I ($I \leq 0.5$) and X is an even integer dependent only on the stoichiometry and charge of the ions involved. Activity correction formulae for ionic equilibria involving classes of ligands (amino acid, inorganic, amine, and organic acid) also were developed. The general formula predicts stability constant corrections within 0.1 log unit for 87% of the data used at ionic strength 0.1 and 64% of the data at ionic strength 0.5. In addition, single ion activity coefficients as a function of ionic strength, $0 < I \leq 0.5$, are presented.

Sydor, M. 1980. Remote Sensing of Particulate Concentrations in Water. Applied Optics 19(16): 2794-2800.

Determination of residual radiance is essential in remote sensing measurements of suspended solids in the absence of real-time ground-truth data. We present some typical background corrections for Lake Superior and determine the spectral distribution of the residual radiance from three major categories of turbidity in the lake. The results tested with Landsat 2 digital tape data indicate that for large bodies of water general information on atmospheric scattering, water clarity, and optical properties of suspended solids enables one to estimate the concentration of particulates to within ±0.5 mg/liter in the absence of real-time ground-truth data.

Thomann, R. V., and J. S. Segna. 1980. Dynamic Phytoplankton-Phosphorus Model of Lake Ontario: Ten-Year Verification and Simulations. IN: Phosphorus Management Strategies for Lakes, Chapter 7, (R. C. Loehr et al., eds.), pp. 153-190, Ann Arbor Science, Ann Arbor, Michigan.

The ability of a 10-year data base afforded the opportunity to test the credibility of a dynamic phytoplankton-phosphorus model of Lake Ontario. Original kinetic structure is updated to include diatom and non-diatom functional phytoplankton groups. The results of the verification of the 10 years of record indicate an overall median relative error of about 20% of the updated kinetics. The application of the model to the

1967-1976 data set appears to indicate a limitation of diatoms by silica in the spring, followed by a growth of non-diatom phytoplankton which tends to be controlled by phosphorus.

The short-term forecasts under an assumed input load scenario indicate that the 1978 hypolimnion total phosphorus levels of about 18 µg P/l in the lake are a response to a rather steep decline in the load between 1976 and 1977. The long-term simulation indicates that the total phosphorus may decline to 10 µg P/l under a 7000 metric ton/yr target load. About 40% of the projected 10 µg P/l is available phosphorus. The response in total phosphorus is approximately linear to the external load. The simulations indicated that the response in chlorophyll would not be as marked and would, in general, be difficult to detect. This is due to the calculated silica limitation of diatoms, which, therefore, do not respond to a phosphorus management program, in terms of phytoplankton, will be in the non-diatom group, which is estimated to be markedly reduced by a reduction in phosphorus load.

Thompson, K. W., A. C. Hendricks, and J. Cairns, Jr. 1980. Acute Toxicity of Zinc and Copper Singly and in Combination to the Bluegill (*Lepomis macrochirus*). Bull. Environ. Contam. Toxicol. 25: 122-129.

Zinc and copper are common components of aquatic effluents from various industrial and mining sources. The acute toxicity of various compounds of Cu and Zn has been determined for many species of fish using continuous flow as well as static toxicity tests under different chemical, temperature, and temporal regimes. Similarly, the toxicity of mixtures of these two, as well as of more complex mixtures of heavy metals, has been studied by many researchers. While many of these studies report the toxicity of Cu and/or Zn to the bluegill (*Lepomis macrochirus*), to our knowledge the literature does not mention the acute toxicity of mixtures of these two metals to this species. The present study was undertaken to investigate the acute toxicity of divalent Zn-Cu mixtures to the bluegill. The LC50 value calculated from the combined tests for Zn was 3.2 mg/l with 95% confidence limits (C.L.) of 2.1 - 4.6 mg/l and an LC50 of 1.0 mg/l for Cu (C.L. = 0.85 - 1.2 mg/l). Tests with Zn and Cu gave an LC50 of 1.4 mg/l for Zn (C.L. = 1.0 - 2.0 mg/l) and one of 0.4 mg/l for Cu (C.L. = 0.3 - 0.6 mg/l). The markings additive index (MAI) was determined to be +0.218 (C.L. = -0.64 and +1.30). Since 0 is contained within these limits, the toxicity of Zn-Cu mixtures to bluegills was additive under the conditions of these tests.

Vasseur, B., L. Funkquist, and J. F. Paul. 1980. Verification of a Numerical Model for Thermal Plumes. Swedish Meteorological and Hydrological Institute, Hydrology and Oceanography Report No. 24. 122 pp.

This report describes a numerical model used to study thermal effects of waste heat discharge into natural water bodies and discusses a number of verifications of the model against data obatined for several Swedish power plant discharges. The model is based on the three-dimensional, time-dependent conservation laws for mass, momentum, and energy. Applications of the model are presented and the effects of important mixing mechanisms are illustrated. Important plume characteristics like surface area of heated water, vertical extent of plume, and centerline temperature decay have all been successfully simulated. The verification study demonstrates that recirculation of cooling water is well described by the model. This work suggests increased use of this type of model study, both in planning of new locations for power plants and in the monitoring of the environmental effects of the discharged heat.

Vodicnik, M. J., A. H. Glickman, D. E. Rickert, and J. J. Lech. 1980. Studies on the Disposition and Metabolism of Pentachloroanisole in Female Mice. Toxicol. Appl. Pharmacol. 56: 311-316.

Pentachlorophenol (PCP) has been shown to be methylated to O-methyl-PCP, pentachloroanisole (PCA), in various biological systems. The disposition and metabolism of PCA were studied in female mice to which the compound was administered at a dose of 20 mg [^{14}C]PCA/kg. Elimination of [^{14}C]PCA equivalents from mouse tissues was rapid, with half-lives ranging from 5 to 10 hr in all tissues examined except liver. Excretion of ^{14}C was primarily via the urine, in which a PCP conjugate, free PCP, and an oxidation product, tetrachlorohydroquinone, were demonstrated. Free PCP and its conjugate were also present in feces. There was no evidence for the presence of parent PCA in either urine or feces. Thus the half-lives of elimination and metabolite patterns resulting from treatment of mice with PCA approximated those seen following PCP administration to rodents. These data suggest that PCA must be demethylated prior to excretion.

Will-Wolf, S. 1980. Effects of a "Clean" Coal-Fired Power Generating Station on Four Common Wisconsin Lichen Species. The Bryologist 83(3): 296-300.

Algal plasmolysis percentages and other morphological characteristics of _Parmelia bolliana_ Mull. Arg., _P. caperata_ (L.) Ach., _P. rudecta_ Ach., and _Physcia millegrana_ Degel. were compared for specimens growing near to and far from a rural coal-fired generating station in south central Wisconsin. SO_2 levels were 389 $\mu g/m^3$, maximum 1 hr level, and 5-9 $\mu g/m^3$, annual averages. _Parmelia bolliana_ and _P. caperata_ showed evidence of morphological alterations near the station; _P. rudecta_ and _Physcia millegrana_ did not.

Will-Wolf, S. 1980. Structure of Corticolous Lichen Communities Before and After Exposure to Emissions from a "Clean" Coal-Fired Generating Station. The Bryologist 83(3): 281-295.

> Lichen communities of black oak group (Quercus (Erythrobalanus) spp.) tree trunks in 29 study sites near the rural Columbia generating station, Portage, Wisconsin, were surveyed before (1974) and three years after (1978) station operations began, to determine if SO_2 air pollution from the station had affected the communities. SO_2 emissions from the station were relatively small: maximum 1 hr level was 389 μg SO_2/m^3 (15 pphm) and annual average concentrations were 5-9 μg SO_2/m^3 (0.20-0.35 pphm). Some differences between lichen communities in higher- and lower-SO_2 impact areas could be seen in the 1978 survey. No lichen species were lost due to SO_2, but communities in higher-SO_2 areas exhibited more changes in species frequencies between 1974 and 1978 than did communities in lower-SO_2 areas. Several common lichen species showed altered patterns of distribution and abundance in higher-SO_2 impact areas. These changes were generally consistent with previously known relative SO_2 sensitivities of the lichen species involved. However, the lichen community changes reported here are associated with lower SO_2 levels than those shown to cause injury or death to lichen species to previous studies.

Winner, R. W., M. W. Boesel, and M. P. Farrell. 1980. Insect Community Structure as an Index of Heavy-Metal Pollution in Lotic Ecosystems. Can. J. Fish. Aquat. Sci. 37(4): 647-655.

> Data from two streams suggest that macroinvertebrate community structure exhibits a predictable, graded response to heavy-metal pollution. In the more heavily stressed sections of both streams, macroinvertebrates, other than tubificid worms and chironomids, were virtually eliminated from rock-rubble, riffle habitats. Midge larvae comprised 75 to 86% of all insects collected from the most grossly polluted stations and less than 10% of the insect communities at the least polluted stations. The correlation coefficient for percentage of chironomids in relation to copper concentration was +0.93 ($P \leq 0.01$). Changes in the coefficient of variation (CV) of percentage of chironomids per sample exhibited a consistent pattern. The lowest CV was at the most polluted stations and the CV increased along a gradient of decreasing metal concentrations, reaching maximum values at the least polluted stations. The number of species of chironomids was inversely related to the proportional density of the family in samples. In Elam's Run, the number of species of chironomids identified in samples increased from 15 at the most polluted station to 39 at the least polluted stations. Fifty-seven species of midges were collected along the 3-km stretch of this grossly polluted stream. Caddisflies were numerically important at the intermediately polluted stations in both streams. Mayflies occurred only at the least polluted stations. We hypothesize that heavily polluted habitats are dominated by midges, moderately polluted habitats by midges and caddisflies, and minimally polluted or unpolluted habitats by caddisflies and mayflies. Since there appears to be a direct relationship between the fraction of a community composed of chironomids and the degree of pollution, we suggest that the percentage of chironomids in samples may be a useful index of heavy-metal pollution.

EPA RESEARCH REPORTS

Andren, A., M. Anderson, N. Loux, and R. Talbot. 1980. Element Flow in Aquatic Systems Surrounding Coal-Fired Power Plants. Wisconsin Power Plant Impact Study. U.S. Environmental Protection Agency, Duluth, Minnesota, Publication No. EPA-600/3-80-076. 94 pp.

> Water quality parameters of a 192-ha (480-acre) cooling pond adjacent to the Columbia Generating Station, Portage, Wisconsin, have been investigated. Anlayses were made for major and minor elements, nutrients, pH, alkalinity, O_2, chloroorganics, phenols, and polyaromatic hydrocarbons. Similar parameters were also measured in the nearby fly ash discharge basin and its associated drainage stream. Laboratory dissolution and precipitation studies of fly ash were performed in an effort to understand the chemistry of the discharged ash water and its potential effects on receiving waters. Mass balance calculations were made and are presented to ascertain whether the cooling pond acts as an efficient sink for inorganic and organic compounds, and if so, what the fate of these compounds is. Data presented in this report are also discussed in terms of plant operation characteristics. Remedial procedures are presented which could alleviate present and anticipated problems.

Andrews, C. B., and M. P. Anderson. 1980. Impacts of Coal-Fired Power Plants on Local Gound-Water Systems. Wisconsin Power Plant Impact Study. U.S. Environmental Protection Agency, Duluth, Minnesota, Publication No. EPA-600/3-80-079. 215 pp.

> Quantitative techniques for simulating the impacts of a coal-fired power plant on the ground-water system of a river flood-plain wetland were developed and tested. Effects related to the construction and operation of the cooling lake and ashpit had the greatest impact. Ground-water flow system models were used to simulate ground-water flows before and after the cooling lake and ashpit were filled. The simulations and field data indicate that the cooling lake and ashpit altered local flow systems and increased ground-water discharge. Chemical changes in the ground-water system were minor. Contaminated ground water was confined to a small area near the ashpit. Thermal changes in the ground water are a major impact of the cooling lake. Changes in water temperature and levels have altered the vegetation of the wetland, a major ground-water discharge area. Ground-water temperature near the cooling lake were monitored. A model was used to simulate the response of subsurface temperatures to seasonal changes in a lake and air temperatures. Long-term substrate temperature changes expected in the wetland were predicted. Using ground-water temperatues to estimate flow rates was investigated. Simulated temperature patterns agreed with field data, but were sensitive to the distribution of subsurface lithologies. It is predicted that by 1987 ground-water temperatures will be increased, resulting in an increase in ground-water flow.

Aulerich, R. J., and R. K. Ringer. 1980. Toxicity of the Polychlorinated Biphenyl Aroclor 1016 to Mink. U.S. Environmental Protection Agency, Duluth, Minnesota, Publication No. EPA/600-3-80-033. 32 pp.

> Effects of the PCB Aroclor 1016 on reproduction, growth, and survial of mink (Mustela vison) were investigated. Mink raised according to commercial mink-ranch procedures were fed diets that contained 0, 2, 10, and 25 ppm Aroclor 1016 for up to 18 months. Reproduction was not adversely affected, although kit growth and survival were suboptimum in some of the treated groups. No hematologic differences were observed between the treated and non-treated mink, but heart weight increased and kidney weight decreased in the older animals of two of the three PCB-treated groups. No consistent gross lesions associated with PCB toxicity were observed. The PCB residue in mink tissues was directly related to the quantity of Aroclor 1016 in the diet. Residues in mink kits suggest that Aroclor 1016 passes the placental barrier.

Basch, R. E., C. H. Pecor, R. C. Waybrant, and D. E. Kenaga. 1980. Limnology of Michigan's Nearshore Waters of Lakes Superior and Huron. U.S. Environmental Protection Agency, Duluth, Minnesota, Publication No. EPA-600/3-80-059. 189 pp.

> Limnological assessments, including water and sediment chemistry, bacterial densities, zoo- and phyto-plankton and benthic macroinvertebrate community structure, and fish contaminants, were performed at 24 locations in Michigan's nearshore waters of Lakes Superior and Huron in 1974 and 1975. The nearshore waters of Lake Superior were all oligotrophic with generally high water quality as reflected by consistently high dissolved oxygen, reactive silica and nitrate, and low phosphorus, total dissolved solids (TDS), chlorophyll a and bacterial densities. A statistical trend analysis based on 1974 through 1976 (GLECS) data indicated significant increases in the concentrations of dieldrin, DDT and mercury in Lake Superior lake trout. These same data show no statistical changes in PCB concentrations from 1974 to 1976.
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> The nearshore waters of Lake Huron were oligotrophic in the northern section and became mesotrophic at the southern end of the lake. Eutrophic conditions were found at Alpena Harbor and Saginaw Bay. Areas of severe water quality degradation occured at Alpena and Saginaw Bay as a result of large inputs of phosphorus and TDS. A statistical analysis based on 1975 through 1978 GLECS data suggested a peak in 1976 dieldrin, DDT and mercury in Lake Huron lake trout. The same data showed no statistical changes in PCB concentrations from 1975 through 1978.

Bierman, V. J., Jr., and D. M. Dolan. 1980. A Spatially-Segmented Multi-Class Phytoplankton Model for Saginaw Bay, Lake Huron. IN: Proceedings of the Second American-Soviet Symposium on the Use of Mathematical Models to Optimize Water Quality Management, Section 17 (W. R. Swain, and V. R. Shannon, eds.), pp. 343-365, U.S. Environmental Protection Agency, Duluth, Minnesota, Publication No. EPA-600/9-80-033.

> The principal issue addressed in the development of the present model was cultural eutrophication, defined as overproduction of phytoplankton biomass due to increased nutrient loadings. The purpose of the modeling effort was to develop a deterministic phytoplankton simulation model that could describe the cause-effect connection between external nutrient loading and phytoplankton growth in Saginaw Bay. The objectives were twofold: first, to gain insight into the relevant physical, chemical, and biological processes affecting phytoplankton growth; and second, to use the model as a tool for comparing the future effects of various wastewater management strategies.
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> The purpose of this paper is to present results of the preliminary calibration phase of the phytoplankton modeling effort. Calibration results will be presented graphically, as well as in terms of statistical tests for goodness of fit between model output and field data. In addition to model calibration results, field data will be presented which illustrate the large gradients in water quality that exist among the five spatial segments in Saginaw Bay. These gradients have a strong impact on the model development effort because it is difficult to obtain a unified set of kinetics which can describe phytoplankton dynamics simultaneously in all five segments.

Bierman, V. J., Jr., and D. M. Dolan. 1980. Responses of Saginaw Bay, Lake Huron, to Reductions in Phosphorus Loadings from the Saginaw River. U.S. Environmental Protection Agency, Duluth, Minnesota, Publication No. EPA-600/3-80-099. 84 pp.

> The purpose of this report is to present results of phosphorus load reduction simulations based on refinements to the state of the art of mathematical modeling research on Saginaw Bay. These refinements were developed subsequent to the Task Group III, a bilateral technical group to review phosphorus loadings (Vallentyne and Thomas 1978). One objective is to provide additional information to the International Joint Commission (IJC), the State of Michigan, and other appropriate planning agencies for evaluating the scientific credibility and the degree of accuracy of the WQA loading objective for Saginaw Bay. Another objective is to document these predictive results prior to a comprehensive re-survey of Saginaw bay being conducted in 1980.

Bott, T. L., R. Patrick, R. Larson, and C. Rhyne. 1980. The Effect of Nitrilotriacetic Acid (NTA) on the Structure and Functioning of Aquatic Communities in Streams. U.S. Environmental Protection Agency, Duluth, Minnesota, Publication No. EPA-600/3-80-050. 173 pp.

> Communities established in microcosms and ecosystem streams in a greenhouse were exposed to .02-2 mg/1 NTA, a range including most expected environmental levels. Higher concentrations were used in some laboratory and screening experiments. NTA at 2 and 20 mg/1 had only slight effects on algal community structure and function and 2 mg/1 protected organisms from the toxic effects of approximately 100 μg Cu^{++}/1. Protection from the toxicity of 30 μg Cu^{++}/1 was also obtained in a 3 month experiment conducted in ecosystem streams with natural sediments and more complex communities. NTA at 2 mg/1 did not result in increased concentrations of Zn, Fe, Mn, Mg, or Cu in algae, *Anacharis*, *Lemna*, *Planaria*, and *Tubifex* spp.; Zn concentrations in algae, *Anacharis* and *Lemna* were frequently reduced; accumulation of added Cu by tubificids was not prevented by NTA. Bacterial communities adapted to 0.02-20 mg NTA/1 and degraded the compound under aerobic conditions. Glucose metabolism of non-NTA degrading bacterial communities measured *in vitro* was protected from metal ion toxicity when Cu, Zn, Ni, Pb, and Hg were complexed with NTA. Glucose metabolism by NTA degrading bacteria was inhibited, however presumably as a result of a release of Cd, Cu, and Zn, ions from concomitant NTA degradation. Substantial extraction of metals from sediments occurred at 10^{-3} *M* (200 mg/1) but not at 10^{-5} or 10^{-7} *M* NTA. Although NTA was relatively resistant to chlorination, IDA in concentrated solution, reacted rapidly with aqueous chlorine to produce an unstable product with oxidizing properties, presumably N-chloro IDA. Both NTA and IDA could be photooxidized in the presence of a sensitizer, but the reactions were very slow.

Broderius, S. J., and L. L. Smith, Jr. 1980. Direct Photolysis of Hexacyanoferrate complexes: Proposed applications to the aquatic environment. U.S. Environmental Protection Agency, Duluth, Minnesota, Publication No. EPA-600/3-80-003. 60 pp.

> The theory and computations described by Zepp and Cline (1977) were experimentally tested in predicting the direct photolysis rates of dilute hexacyanoferrate (II) and (III) solutions in the aquatic environment. Essential information for these calculations includes the quantum yield for the photoreaction, molar extinction coefficients of the complex ions for wavelengths >295 nm, solar irrradiance data used to calculate specific sunlight absorption rates, and the assumption that the photolysis reaction obeys a first-order kinetic rate expression. Direct photolysis rates of the irreversible photochemical reactions are calculated as a function of the time of year, latitude, time of day, meteorological conditions, and depth in natural water bodies. Light of wavelengths <480 nm is active in the photolysis reactions, and pH, temperature, and concentration all affect the reaction to varying

degrees. Assuming first-order kinetics, in which the rate constant was approximately concentration independent within the range of 25-100 μg/l total cyanide, the minimum quantum yields of HCN formation were 0.14 and 0.0023 for the iron (II) and (III) complexes, respectively. These values correspond to minimum, near surface, midday half-lives at midsummer of about 18 and 64 min at St. Paul, MN. The photolysis rate at various fixed depths in a natural water column, when compared with that at the surface, decreases exponentially with depth. It is suggested that the photolysis reactions are enhanced by suspended material in turbid waters because of the forward scattering of light when compared with that theoretically calculated from beam attenuation coefficients. Hexacyanoferrate (II) and (III) solutions of equal initial total cyanide concentration respond photochemically quite differently from one another in solutions prepared with deionized water, but respond in a similar manner for solutions prepared with natural waters. The potentially rapid photodecomposition of iron-cyanides with formation of HCN suggest that this phenomenon may be of toxicological importance under certain environmental conditions.

Buchanan, W. J., and F. L. Scarpace. 1980. Mapping Vegetation Complexes with Digitized Color Infrared Film: Wisconsin Power Plant Impact Study. U.S. Environmental Protection Agency, Duluth, Minnesota, Publication No. EPA-600/3-80-054. 72 pp.

Environmental inventories of sites typically include some efforts to map land cover. These maps are used to describe the existing environment or to monitor and assess environmental changes. Digitized photo-analysis was investigated in this context for mapping vegetation complexes. The goal was to assess the utility of this technique for site analysis by testing several variables.

Some images were successfully classified, but other classification attempts were abandoned; digitized film analysis was not an entirely reliable mapping technique. Resource signatures often overlapped. Additional research should determine if multiseasonal data overlayment, data-enhancement transformations, and machine adjustments can create the necessary reliability for operational applications.

Canale, R. P., L. M. DePalma, and W. F. Powers. 1980. Sampling Strategies for Water Quality in the Great Lakes. U.S. Environmental Protection Agency, Duluth, Minnesota, Publication No. EPA-600/3-80-055. 87 pp.

The major goal of this project was to investigate the potential applications of Kalman filtering and modern optimization techniques to the design of sampling strategies for water quality in the Great Lakes. Two representative problems of general limnological interest with considerably different characteristics were studied. The first problem concerns sampling requirements for long-term trend detection of chloride and total phosphorus concentrations in Lake Michigan. A minimum-cost sampling strategy has been determined in association with the Kalman filter and mathematical models that can detect changes of 1.0 mg Cl/l and 1.0 μg P/l in Lake Mighigan and 90 percent probability. The cost of the sampling program is considerably less than monitoring programs designed without benefit of mass balance models and Kalman filter data processing. An investigation was conducted to determine the sensitivity of the optimal cost to the accuracy of the mass balance model parameters. It is concluded that the calculated sampling cost is most sensitive to the variance in the apparent phosphorus settling velocity, not as sensitive to the accuracy of laboratory analyses, and rather insensitive to the accuracy of the effective flow at the Straits of Mackinac and atmospheric loads. The second problem concerns the potential applicability of Kalman filtering techniques for concentration estimation and parameter identification for a phytoplankton and nutrient cycling model for Saginaw Bay.

Coward, N. A., and J. W. Horton. 1980. Static Coal Storage. Chemical Effects on the Aquatic Environment. U.S. Environmental Protection Agency, Duluth, Minnesota, Publication No. EPA-600/3-80-083a. 84 pp.

The aqueous leaching of heavy metals from soft coal has been examined under a variety of conditions. Variables examined were pH, particle size, rate of flow, time of contact, and oxygen of nitrogen atmosphere. Simple leaching of coal from Western mines with pure water does not remove large amounts of metal. Metal removed was in most cases about 0.1% to 0.5% of the total metal in the coal. Extended, successive leaches (of about one week duration) and leaches in mildly acid (acetic acid-acetate buffer; pH≃4.7) tended to remove larger amounts of some metals. Leaching with a strong complexing agent removes relatively larger amounts of metal. When placed in contact with water previously spiked with metal ions, the coal actually reduces the aqueous concentration of many metal ions.

Continuous flow and simple shaker experiments correlate qualitatively with each other.

Considerable variation was found between Eastern and Western coal and also between different samples of Western coal.

Davis, L. R., G. W. Bowers, and M. K. Goldenblatt. 1980. Workbook/Users Manual for Prediction of Instantaneously Dumped Dredged Materials. U.S. Environmental Protection Agency, Duluth, Minnesota, Publication No. EPA-600/3-80-034. 224 pp.

This manual describes the operation and use of a computer model developed by Koh and Chang, modified in 1976 for the Corps of Engineers and further updated by JBF Scientific Corp., that predicts the physical fate of dredged material instantaneously released into a water column. The model predicts the spatial distribution of various components of the dumped material as a function of time. Outputs include material concentration and position while in the water column, and material mound height and concentration after bottom impact.

Included in this report are a description of the model's structure, a complete explanation of its input/output formats, and in addition, the model has been run for a matrix of input conditions. Both the input and output of these runs are presented as tables in dimensionless form. These working tables can be used to approximate the fate of dredged material for a wide variety of input conditions without requiring the user to actually run the model. Several examples showing how these tables can be used are also given.

Dill, D. C., W. M. McCarty, H. C. Alexander, E. A. Bartlett. 1980. Toxicity of 1,1-Dichloroethylene (Vinylidene Chloride) to Aquatic Organisms. U.S. Environmental Protection Agency, Duluth, Minnesota, Publication No. EPA-600/3-80-057. 26 pp.

Studies were conducted to determine the acute toxicity of 1,1-dichloroethylene [(vinylidene chloride) VDC] to fish and macroinvertebrates. The methods included a 96-hour static toxicity test using fathead minnows, Pimephales promelas Rafinesque; a 48-hour static toxicity test using water fleas, Daphnia magna Straus; and a 13-day flow-through toxicity test using the fathead minnow, Pimephales promelas Rafinesque. The 96-hour static LC50 value for fathead minnows was 169 (161 to 179) mg/l. The LC50 value is the calculated concentration of toxicant which would kill 50 percent of the test organisms within a specified time period, e.g., 96 hours. The 48-hour static LC50 for daphnids was 11.6 (9.0 to 14.0) mg/l. The 96-hour flow-through LC50 value for fathead minnows was 108 (85 to 117) mg/l. The threshold LC50 value in flowing water was demonstrated after 7 days to be 29 (23 to 34) mg/l. The threshold LC50 value is achieved when there is no further decine in the LC50 value over a period of three to four days or more. Loss of body equilibrium (swimming disorientation) was the major sublethal toxic effect noted in the static and flow-through fish tests. Many fish affected in the static test recovered in 48 hours, perhaps because of volatilization of the toxicant. However, all affected fish in the flow-through test died by day 7. The 24- and 48-hour LC50 water flea test values were identical, probably because of volatilization of the test material during the first 24 hours. The difference in the static and flow-through fish toxicity values stresses the importance of conducting a flow-through test with volatile chemicals to adequately determine acute and longer term exposure effects (>96 hours).

DiToro, D., and J. P. Connolly. 1980. Mathematical Models of Water Quality in Large Lakes. Part 2: Lake Erie. U.S. Environmental Protection Agency, Duluth, Minnesota, Publication No. EPA-600/3-80-065. 249 pp.

This research was undertaken to develop and apply a mathematical model of the water quality in large lakes, particularly Lake Huron and Saginaw Bay (Part 1) and Lake Erie (Part 2).

A mathematical model was developed for analysis of the interactions between nutrient discharges to Lake Erie, the response of phytoplankton to these discharges, and the dissolved oxygen depletion that occurs as a consequence. Dissolved oxygen, phytoplankton chlorophyll for diatoms and non-diatoms, zooplankton biomass, nutrient concentrations in available and unavailable forms and inorganic carbon are considered in the model. Extensive water quality data for Lake Erie was analyzed and statistically reduced. Comparison of data from 1970 and 1973-74 to model calculations served for calibration of the model. A verification computation was also performed for 1975, a year when no anoxia was observed.

Recent developments in phytoplankton growth and uptake kinetics are included in this analysis. The methods of sedimentary geochemistry are expanded to include an analysis of sediment oxygen demand within the framework of mass balances. Projected effects of varying degrees of phosphorus removal on dissolved oxygen, anoxic area, chlorophyll, transparency and phosphorus concentration are presented.

DiToro, D. M., and W. F. Matystik, Jr. 1980. Mathematical Models of Water Quality in Large Lakes. Part I. Lake Huron and Saginaw Bay. U.S. Environmental Protection Agency, Duluth, Minnesota, Publication No. EPA-600/3-80-056. 180 pp.

This research was undertaken to develop and apply a mathematical model of the water quality in large lakes, particularly Lake Huron and Saginaw Bay (Part 1) and Lake Erie (Part 2).

A mathematical model of phytoplankton biomass was developed which incorporates both phytoplankton and zooplankton as well as phosphorus, nitrogen and silica nutrient forms. Extensive water quality data for Lake Huron and Saginaw Bay was analyzed and statistically reduced. The model was then calibrated by comparison of computed results to these data.

An exhaustive treatment of the kinetics employed for modeling the eutrophication process is presented. The sensitivity of the model to some of its key parameters is examined. In addition, responses of water quality in Lake Huron and Saginaw Bay system to variations in total phosphorus inputs are projected.

Dolan, D. M. 1980. Optimal Sampling for Long Term Trends in Lake Huron. IN: Proceedings of the Second American-Soviet Symposium on the Use of Mathematical Models to Optimize Water Quality Management, Section 4 (W. R. Swain, and V. R. Shannon, eds.), pp. 58-70, U.S. Environmental Protection Agency, Duluth, Minnesota, Publication No. EPA-600/9-80-033.

A major goal of the International Surveillance Program for the Great Lakes is to detect long-term changes in the concentrations of various parameters in each of the lakes. The techniques discussed in this paper are extremely useful for designing and/or evaluating a plan for trend detection. Even if the model associated with the Kalman filter (an information processing technique combining models calculations and sampling results to estimate a parameter of interest) is inaccurate, the procedure leads to orderly acquisition and evaluation of data pertaining to trend detection. If the model can be improved, significant increases in accuracy can be realized or, alternatively, sampling costs can be decreased. In either case, these techniques provide a systematic way of evaluating a proposed measurement strategy as well as determining if another strategy could give substantial gains in accuracy.

In the case of Lake Huron, application of this procedure has shown that for nutrients, the northern segment of the lake is over-sampled, while the southern segment is under-sampled. This situation can be improved by increasing the number of stations in the southern segment, or by improving the model to be used with the Kalman filter to obtain estimates of trends. These results are probably generalizable to other parameters that could be described well by a simple mass balance, such as conservative substances, radionuclides, some heavy metals and suspended solids. Biological parameters and certain organic contaminants would require a more sophisticated approach.

Eisenreich, S. J., P. J. Emmling, and A. M. Beeton. 1980. Determination of Atmospheric Phosphorus Addition to Lake Michigan. U.S. Environmental Protection Agency, Duluth, Minnesota, Publication No. EPA-600/3-80-063. 60 pp.

Bulk precipitation was collected on a monthly basis in the Lake Michigan basin for 18 months during 1975-1976 to determine atmospheric P loadings to Lake Michigan. The sampling network consisted of bulk collectors at 23 land stations and 2 in-lake buoys located off urban and rural areas. Annual TP loading to Lake Michigan for 1976 based on loading rates of 0.184 and 0.303 $\mu g/cm^2/mo$ for the north and south basins, respectively was 1.69×10^6 kg/year, representing ~16% of the total P budget. North and south basins showed different TP loading properties with ~62% deposting in the south basin. Seasonal variations in loading rates showed maxima in late spring and early summer, and minima in winter. In-lake buoy samplers yielded enhanced loading of TP compared to land stations. Wet-only precipitation concentrations for TP averaged 15% of bulk deposition values. Weighted-average TP concentrations in bulk precipitation were 0.050 and 0.064 mg/l in the north and south basins, respectively. Atmospheric TP loading was closely correlated to Ca and Mg loading, independent of precipitation amount, and exhibited a large dry fall component. Windblown soil and re-entrained dust are believed to be the major sources of atmospheric phosphorus addition to Lake Michigan.

Gerhart, D. Z., J. E. Richter, S. J. Curran, and T. E. Robertson. 1980. Algal Bioassays with Leachates and Distillates from Western Coal. U.S. Environmental Protection Agency, Duluth, Minnesota, Publication No. EPA-600/3-80-051. 77 pp.

The objective of this research was to assess the effects on freshwater algae of materials derived from coal storage piles. Coal leachates and distillates were prepared in the laboratory from low-sulfur Montana coal. Three types of algal bioassasys were conducted.

1). A laboratory stream facility was constructed which supported periphyton communities of 50-80 species growing on artificial substrates. These communities generally showed stimulation of growth and some species composition changes in response to coal leachates. Coal distillates inhibited growth. Periphyton exposed to distillates accumulated aliphatic hydrocarbons.

2) Short-term laboratory bottle tests with test species of algae generally showed growth inhibition in response to leachates and distillates. When distillates were bubbled to remove volatile organic compounds, growth stimulation was observed.

3) Three in situ experimenters in a small lake were conducted with coal distillates. Increases in algal biomass and bacterial populations in distillate-treated enclosures were observed in each of these tests.

Glass, G. E., and O. L. Loucks (eds.). 1980. Impacts of Airborne Pollutants on Wilderness Areas Along the Minnesota-Ontario Border. U.S. Environmental Protection Agency, Duluth, Minnesota, Publication No. EPA-600/3-80-044. 199 pp.

The goal of this study was to examine previously unanswered questions concerning potential effects of the proposed Atikokan, Ontario power plant on ecosystems in the Boundary Waters Canoe Area Wilderness (BWCA) and Voyageurs National Park (VNP) of Minnesota by using the most relevant data and analytical methods. The principal steps were to focus on: (1) the ultimate deposition of emissions from the plant (rather than only on pollutant concentration), (2) the use of a time-varying grid model with provision for atmospheric transformations, and (3) a detailed review of all available data from the region on atmospheric deposition of pollutants, water quality, and effects. The results are considered in relation to a review of responses by terrestrial and aquatic organisms to changes in the chemistry of this environment.

The sensitive aquatic and terrestrial receptors in the BWCA-VNP region are described quantitatively, and this information is assessed in terms of what is currently known about the impacts of atmospheric pollutants. Specific conclusions based on factual information, probable consequences, and possible impacts of the proposed coal-fired power generating station at Atikoken are presented.

The study supports, in part, the conclusions reached previously concerning the predicted air concentrations of sulfur dioxide, but differs significantly with the conclusions concerning the significance of future impacts. When the total emissions from the proposed power plant are considered, the increased loadings of sulfuric and nitric acids, fly ash, and mercury as an addition over and above other regional sources will, with high probability, have significant consequences for the sensitive receptors in the BWCA-VNP region, especially for the future of sport fisheries and other aquatic resources.

Goettl, J. P., Jr., and J. W. Edde. 1980. Environmental Effects of Western Coal Surface Mining. Part VIII. Fish Distribution in Trout Creek, Colorado, 1975-1976. U.S. Environmental Protection Agency, Duluth, Minnesota, Publication No. EPA-600/3-80-070. 36 pp.

A study was conducted on Trout Creek in northwestern Colorado during 1975-1976 to assess the effects of drainage from an adjacent surface coal mine on the distribution of fishes in the creek, and to relate their distribution to physical and chemical variables. A second objective was to determine the possible toxicity of surface coal mine drainage water on fish stocked in ponds receiving surface and groundwater run-off from the mine.

Results did not indicate any direct effects of mine drainage water on the distribution of fishes in Trout Creek, although possible effects may have been masked by elevations, stream flow, streambed alterations, and agricultural irrigation return flows. Brook trout (*Salvelinus fontinalis*) was the dominant salmonid species in the upper reaches of the creek; rainbow trout (*Salmo gairdneri*) and brown trout (*S. trutta*) were found only in the region of the mine. Mottled sculpin (*Cottus bairdi*) and speckled dace (*Rhinichthys osculus*) were the most common fishes found throughout and at all but the uppermost reaches, respectively.

Rainbow trout stocked in mine seepage water ponds for a year evidenced high survival rates over an eight-month period during the winter, but fared poorly during the ensuing summer months, this latter most probably because of extremely high water temperatures. There was no apparent evidence of toxicity to the fish from contaminants in the mine pond water.

Great Lakes Laboratory. 1980. Lake Erie Nutrient Control: Effectiveness Regarding Assessment in Eastern Basin. U.S. Environmental Protection Agency, Duluth, Minnesota, Publication No. EPA-600/3-80-067. 100 pp.

A three-year synoptic monitoring program was conducted on 26 stations from 1973-75. Data generated included major nutrients, temperature structure and oxygen depletion as well as phytoplankton, zooplankton, and benthic macroinvertebrate dynamics. The Basin was separated into five discrete areas based on physico-chemical variables. While anoxia was not observed, there was a hypolimnetic oxygen demand of 0.011 g O_2/m^3/day. The Eastern Basin has remained relatively stable over the past five years with the exception of a decrease in phytoplankton biomass, increase in nitrogen, and a doubling of benthic macroinvertebrates. From a trophic standpoint, the Basin can be classified as mesotrophic. Reductions in algal growth may be in response to pollution abatement, particularly phosphorus.

Herdendorf, C. 1980. Lake Erie Nutrient Control Program - An Assessment of Its Effectiveness in Controlling Lake Eutrophication. U.S. Environmental Protection Agency, Duluth, Minnesota, Publication No. EPA-600/3-80-062. 380 pp.

A three-year assessment of nutrient control efforts was conducted in the western and central basins of Lake Erie during the period June 1973 to June 1976. The objective of the study was to determine recent trends in lake eutrophication and water quality which may be related to recent attempts to control nutrient loadings to these basins. The assessment was accomplished by visiting approximately 50 stations at nearly monthly intervals during the ice-free periods. Over 25 water quality, meteorologican and biological parameters were routinely determined shipboard or on samples collected at a typical station. Measurements were taken at several depths in order to characterize the various strata of water in the lake and to permit volume-weighted calculation of nutrient concentrations and quantitites. Data from previous limnological surveys as far back as 1928 were compared with the results of the present study to establish longterm trends, as well as recent trends since the last comprehensive survey in 1970.

The fundamental conclusion of this assessment is that during the first half of this decade no significant decrease in the loading of nutrients to Lake Erie has taken place. Therefore, during this period the concentrations and quantities of nutrients within the waters of the lake have remained relatively stable. An encouraging sign of nutrient control is that although no decreases have been observed, the constant increases which have taken place in preceeding decades have been stopped.

Holland, R. E. 1980. Seasonal Fluctuations of Major Diatom Species at Five Stations Across Lake Michigan, May 1970 - October 1972. U.S. Environmental Protection Agency, Duluth, Minnesota, Publication No. EPA-600/3-80-066. 95 pp.

> From 27 May, 1970 to 4 October, 1972, we collected water samples from five stations on a transect across Lake Michigan from Milwaukee, Wisconsin to Ludington, Michigan. At all stations in the three years sampled, diatoms reached their highest numbers in late spring or summer. These periods of greatest abundance of total diatoms were the result of the rapid growth of one or two species. *Stephanodiscus hantzeschii* was the dominant species at Station 1, off Milwaukee and *Rhizosolenia eriensis* was the dominant species or one of the predominant forms at the other 4 stations. *Cyclotella stelligera* was the dominant diatom when highest yearly numbers were reached at Stations 3 and 5 in August, 1972. Highest winter numbers were reached at Station 1 on 22 February, 1972 when total frustules were 960/ml, and *Stephanodiscus minutus* was dominant at all stations. Solar radiation appeared to be the limiting factor in the productivity of winter plankton.

Isensee, A. R., and R. S. Yockim. 1980. Freshwater Micro-Ecosystem Development and Testing of Substitute Chemicals. U.S. Environmental Protection Agency, Duluth, Minnesota, Publication No. EPA-600/3-80-008. 36 pp.

> This research project was initiated with the overall objective of developing additional and better techniques for studying pesticides in aquatic model ecosystems.
>
> To achieve this objective, a model ecosystem was designed and built that utilizes the continuous dosing, flow-through system routinely used for chronic fish toxicity testing in combination with the organisms used in static model ecosystem testing. A previously developed recirculating static model ecosystem (simulating a sediment or erosional pesticide source) was simultaneously used with the flowing water system (simulating an effluent pesticide source) to test the behavior of three pesticides (pentachloronitrobenzene (PCNB), simazine, and trifluralin).
>
> Conditions in the static system favored pesticide degradation while the flowing system insured continuous pesticide exposure to the organisms. pesticides were introduced in the systems at rates ranging from 0.1 to 100 ppb (flowing; directly into water). Organisms included daphnids (*Daphnia magna*), algae (*Oedogonium cardiacum*), snails (*Helisoma* sp.), and mosquito fish (*Gambusia affinis*).
>
> The total amount of ^{14}C-labeled PCNB (parent compound plus metabolites) accumulated by all organisms was about the same in each of the two ecosystems (for similar treatment rates). Pentachloronitrobenzene content in organisms reached equilibrium levels with water in 3 to 7 days and decreased 50 to 95% when placed in untreated water for 10 days.

Variability between samples was high, primarily at the lower treatment rates and for algae. Analytical problems and precipitation between samples was high, primarily at the lower treatment rates and for algae. Analytical problems and precipitation between samples was high, primarily at the lower treatment rates and for algae. Analytical problems and precipitation difficulties in the flowing system were responsible for this variability. Simazine accumulation (parent compound plus metabolites, ^{14}-C-labeled) by snails and fish was similar between systems for similar treatment rates, while algae and daphnids accumulated higher amounts of simazine in the flowing systems than in the static. Also, more degradation products were found in fish extracts from the static than in the flowing systems. Trifluralin was extensively degraded in the static system with very little accumulation of ^{14}C by the organisms. Further, little of the ^{14}C accumulated was trifluralin. Large amounts of trifluralin were accumulated by all organisms in the flowing systems, most of it being the parent compound. Also toxicity to algae and abnormal behavior responses of fish to the highest trifluralin level were observed.

The basic design of the two systems is sufficiently different that they cannot be routinely substituted for each other without first considering such factors as test compound degradability, likely mode of introduction into water and the type of toxicity data desired. However, the flowing system is more versatile in the types of data that can be obtained than either the static or simple flowing chronic testing system, but requires a higher level of design, maintenance, and analytical input than the simpler system.

Jaeger, M. J. 1980. Predicting Effects of an Electric Generating Station on Wetland Passerine Birds: Wisconsin Power Plant Impact Study. U.S. Environmental Protection Agency, Duluth, Minnesota, Publication No. EPA-600/3-80-020. 33 pp.

The distribution of breeding passerines (songbirds) was investigated in a wetland in southern Wisconsin to develop a model for use in predicting changes in bird frequencies resulting from environmental alterations. The wetland is adjacent to the cooling lake of a coal-fired electric generating station. The water levels in the wetland are being altered by the cooling lake's effect on the local ground-water system. The model uses information on distributions of bird species along gradients of water depth and vegetation-structure characteristics and information on the relationships between the characteristics to predict changes in bird species' frequencies resulting from increased water levels. The predictions are qualitative, in that they predict only the direction of the change, not its magnitude. The resulting predictions are: (1) the long-billed marsh wren should increase in frequency; and (2) the swamp sparrow, common yellow throat, and yellow warbler should decrease in frequency. No prediction could be made concerning the frequency of the red-winged blackbird.

Johnson, W. W., and A. M. Julin. 1980. Acute Toxicity of Toxaphene to Fathead Minnows, Channel Catfish, and Bluegills. U.S. Environmental Protection Agency, Duluth, Minnesota, Publication No. EPA-600/3-80-005. 30 pp.

Toxaphene was very toxic to fathead minnows (*Pimephales promelas*), channel catfish (*Ictalurus punctatus*), and bluegills (*Lepomis macrochirus*) in static tests; 96-h LC50's ranged from 2.6 to 20 μg/l at 20 C. Fathead minnows were the least susceptible and bluegill and channel catfish were about equal in susceptibility. Prolonged exposures of 12-34 days in flow-through tests produced time-independent LC50 values of 0.6 to 1.9 μg/l, significantly lower than the 96-h values.

The toxicity of toxaphene was not influenced by variations in pH or water hardness in static tests. Temperature seemed to influence rate of onset rather than degree of response. Toxicities were similar at 20 and 25 C in flow-through tests, however, a decrease in the time required for mortality to become asymptotic with time was observed. Time-independence was reached after 7 to 16 days of exposure at 25 C while 24 to 34 days were required at 20 C.

The life stage of channel catfish most sensitive to toxaphene poisoning was the swim-up fry with a 96-hr LC50 of 0.8 μg/l. Early yolk sac fry were extremely resistant with a 24 h LC50 fo 4.7 mg/l, however, within 96 hours the yolk had adsorbed and the LC50 had declined to 8.0 μg/l.

Kimble, P. F., and K. L. Temple. 1980. Environmental Effects of Western Coal Surface Mining. Part VII. Microbial Effect on the Quality of Leach Water From Eastern Montana Coal Mine Spoils. U.S. Environmental Protection Agency, Duluth, Minnesota, Publication No. EPA-600/3-80-046. 89 pp.

Selected portions of test cores from the overburden of the West Moorhead coal deposit in southeastern Montana were examined for possible addition to leach water of toxic substances and for the presence of iron and sulfur bacteria which might contribute to leaching. Leachates were evaluated by measuring pH, lead, and the effect of the leachates on the *Selenastrum* algal assay.

Both sulfur- and iron-oxidizing bacteria were isolated from a number of core samples. These bacteria differed nutritionally from thiobacilli and from other bacteria known to be involved in oxidizing sulfur and iron. Concentrations of lead in the leachates were comparable; they were not proportional to the lead content of the core samples. Most core samples were nearly neutral in reaction but some were highly acid. All acid leachates were toxic to Selenastrum. For reasons which were not determined, some non-acid leachates were also toxic to *Selenastrum* and some leachates stimulated *Selenastrum* growth.

It is concluded that acid formation in overburden spoils would be a problem only in the circumstance when a potentially acid-forming stratum is so placed during spoil reclamation that it drains directly into a surface stream. It is recommended that laboratory bioassays be used adjunct to chemical analysis for identifying problem strata.

Koch, R. G. 1980. Preliminary Investigations of the Role of Aquatic Macrophytes in Heavy Metal Uptake from Water with Coal Particles. U.S. Environmental Protection Agency, Duluth, Minnesota, Publication No. EPA-600-3/80-083b. 21 pp.

> A survey was made and representative samples of vascular macrophytes from the Superior, Wisconsin-Duluth, Minnesota Harbor were collected in August 1975 and stored in a frozen condition until processed. The processed samples were analyzed for environmentally sensitive metal concentrations by flameless atomic absorption spectrophotometry.
>
> The potential of using *Lemna minor* L. to examine the effects of Western coal upon growth was investigated. *Lemna minor* L. was grown in Lake Superior water in the presence of incremental amounts of particulate coal. Temperature, humidity and light were controlled and growth rates were determined by plant frond counts. Samples of *Lemna* were collected for metal uptake analyses. Preliminary evidence suggested that coal particulates, at certain concentrations, may diminish the growth of this aquatic plant. Increased metal uptake by the plant was noted.

Lech, J., and M. Melancon. 1980. Uptake, Metabolism, and Disposition of Xenobiotic Chemicals in Fish. Wisconsin Power Plant Impact Study. U.S. Environmental Protection Agency, Duluth, Minnesota, Publication No. EPA-600/3-80-082. 157 pp.

> The effects and fate in fish of a number of chemicals, including hydrocarbons and chlorinated hydrocarbons, have been examined. The interactions between these chemicals and fish have been studied using several approaches.
>
> The uptake and elimination of ^{14}C-labeled napthalene, 2-methylnapthalene, 1,2,4-trichlorobenzene, pentachlorophenol, and pentachloroanisole were studied. Each of these chemicals was taken up rapidly by rainbow trout. Increasing the duration of exposure to ^{14}C-napthalene or ^{14}-C-2-methylnapthalene affected the elimination of ^{14}-C-containing components from these fish. Activities of cytochrome P-450-related xenobiotic metabolizing enzymes in rainbow trout livers were induced. The quantities of biliary metabolites in these fish were considerably higher than those found in non-induced trout.
>
> Piperonyl butoxide reduced levels of biliary metabolites of pentachloranisole and di-2-ethylhexyl-phthalate in trout and increased tissue levels of these chemicals. The high levels of biotransformation products of these chemicals found in fish bile during and after exposure to the chemicals in these studies support the possible use of bile sampling in pollutant-modeling programs.

Lee, G. F. 1980. An Evaluation of Hazardous Chemicals in Lake Ontario During IFYGL. U.S. Environmental Protection Agency, Duluth, Minnesota, Publication No. EPA-600/3-80-060. 34 pp.

Data collected during the IFYGL studies (1972-73) on Lake Ontario are summarized relative to the recommended International Joint Commission (IJC) Research Advisory Board water quality objectives or USEPA Quality Criteria for Water. Data from 247 stations are used to summarize information on the following parameters: cadmium, zinc, chromium, copper, fluoride, iron, lead, nickel, manganese, and ammonia. Chlorinated hydrocarbon data for DDT, dieldrin, and PCBs are discussed relative to concentrations determined in water samples and three fish species. Summaries indicate that almost all reported measurements for total cadmium exceed the IJC water quality objective of 0.2 μg/l by at least five times. Values reported for copper also showed a high percentage of measurements equal to or in excess of the recommended IJC water quality objective. Other metals showed more regional patterns of values equaling or exceeding water quality objectives. The concentrations of PCBs, dieldrin and DDT and its metabolites in Lake Ontario water and fish were found to exceed the IJC water quality objectives and the USEPA water quality criteria. If the IFYGL data are representative of Lake Ontario conditions, studies need to be conducted to evaluate whether the "excessive" concentrations are indicative of water quality deterioration.

Lick, W. 1980. The Transport of Contaminants in Lake Erie. IN: Proceedings of the Second American-Soviet Symposium on the Use of Mathematical Models to Optimize Water Quality Management, Section 15 (W. R. Swain, and V. R. Shannon, eds.), pp. 261-305, U.S. Environmental Protection Agency, Duluth, Minnesota, Publication No. EPA-600/9-80-033.

Along with a general discussion of the factors affecting the transport of contaminants in a lake, two specific events have been analyzed: (1) sediment transport in the Western Basin of Lake Erie, and (2) the temperatures, currents, and the transport of contaminants in the Central Basin of Lake Erie during summer stratification.

Reasonable and encouraging agreement between the results of the calculations and observations was obtained. Nevertheless, it is also obvious that a great deal more needs to be done before realistic, quantitative, predictive models of contaminant transport are developed and available for use.

For sediment transport, the research needs are: (1) more qualitative and quantitative knowledge of the entrainment and deposition processes for a wide variety of sediments in lakes, (2) further investigation and verification of bottom stresses due to the combined action of waves and currents, and (3) additional calculations of sediment transport and verification of these calculations, especially for long-term events.

For stratified flow, it is necessary to further investigate, model and verify: (1) short-term events such as upwelling and downwelling due to strong winds, (2) the formation, maintenance, and decay of the thermocline and associated currents, and (3) the dispersion of contaminants during both short-term and long-term events, especially when there is coupling between the stratification, sediment-water exchange, and biochemical processes in the water column.

Mackie, G. L., D. S. White, and T. W. Zbeda. 1980. A Guide to Freshwater Mollusks of the Laurentian Great Lakes with Special Emphasis on the Genus Pisidium. U.S. Environmental Protection Agency, Duluth, Minnesota, Publication No. EPA-600/3-80-068. 150 pp.

Presented here are keys and notes on distribution and ecology for the freshwater snails (Gastropoda), mussels (Unionidae), and fingernail clams (Sphaeriidae) which have been collected from the Laurentian Great Lakes. Including subspecies and forms, 121 taxa are discussed: 47 Gastropoda, 39 Unioinidae, and 35 Sphaeriidae. Relations to substrate preferences and pollution are summarized where known. Special emphasis is given to the sphaeriid genus Pisidium in discussions of morphological variability and characters which will separate the species and forms both in the adult and photomicrographs are presented for all sphaeriid taxa. A limited synonymy has been compiled from publications and reports on the Laurentian Great Lakes and the expanded reference section includes not only citations used in the text but also publications and reports which may aid researchers in more indepth studies of the fauna.

Magnuson, J. J., A. M. Forbes, D. M. Harrell, and J. D. Schwarzmeier. 1980. Responses of Stream Invertebrates to an Ashpit Effluent. Wisconsin Power Plant Impact Study. U.S. Environmental Protection Agency, Duluth, Minnesota, Publication No. EPA-600/3-80-081. 165 pp.

Fly ash from the 527-MW coal-fired Columbia Generating Station Unit I (Columbia Co., Wisconsin) is discharged as a slurry into an adjacent ashpit. Water from the ashpit is pumped to a ditch that joins the ashpit drain and Rocky Run Creek before they reach the Wisconsin River. Habitat alterations have been noted as relatively minor changes in water quality parameters (e.g., alkalinity, hardness, pH, and turbidity), as increased amounts of some dissolved trace elements (Cr, Ba, Al, Cd, and Cu), and as the precipitation of trace elements (Al, Ba, and Cr) into a floc that coats the stream bottoms. The ashpit drain became an unsuitable habitat for aquatic invertebrates after Columbia I began operating.

The conductivity of the effluent increased in January 1977 when sodium bicarbonate was first used to increase the efficiency of the electrostatic precipitators. Since then conductivity measurements have indicated effluent concentration at distances downstream from the generating station.

Rocky Run Creek is still a suitable habitat for many aquatic invertebrates, but evidence of sublethal stresses and habitat avoidance exists. The major effect of Columbia I on aquatic invertebrates is hypothesized to be continued habitat alteration and, in particular, reduced substrate quality and avoidance of unpreferred habitat. The susceptibility of early life stages of crustaceans to the ash effluent may also be important. Acute toxicity to adult forms is unimportant.

Magnuson, J. J., F. J. Rahel, M. J. Talbot, A. M. Forbes, and P. A. Medvick. 1980. Ecological Studies of Fish Near a Coal-Fired Generating Station and Related Laboratory Studies. U.S. Environmental Protection Agency, Duluth, Minnesota, Publication No. EPA-600/3-80-078. 121 pp.

Construction of a coal-fired electric generating station on wetlands adjacent to the Wisconsin River has permanently altered about one-half of the original 1,104-ha site. Change in the remaining wetlands continues as a result of waste heat and ashpit effluent produced by the station. Leakage of warm water from the 203-ha cooling lake is causing a shift in the wetlands from the station's ashpit drain. Since this area was known to have a diverse fish community and to be a spawning ground for Wisconsin River game fish, we studied the effects of this habitat loss and degradation on fish populations. In laboratory experiments we investigated the use of temperature preference and activity as a sublethal bioassay. In selection experiments we examined the potential of fish to evolve metal-tolerant populations in chronically contaminated environments.

Marcus, M. D., H. L. Bergman, D. A. Stoller, S. K. Brown, and P.A. Molhot. 1980. Bibliography of Aquatic Ecosystem Effects Analytical Methods and Treatment Technologies for Organic Compounds in Advanced Fossil-Fuel Processing Effluents. U.S. Environmental Protection Agency, Duluth, Minnesota, Publication No. EPA-600/3-80-026. 362 pp.

Advance fossil-fuel processing operations, including oil-shale retorting, coal gasification, coal liquifaction, and tar-sands recovery, can result in chemically complex aqueous waste effluents. This bibliography compiles much of the recent literature (ca 1970-1977) concerning effects of organic compounds in advanced fossil-fuel processing effluents when discharged into aquatic ecosystems, plus information available on analytical methods and treatment technologies for these organics. To compile the bibliography, nearly 500 organic compounds known to be constituents of fossil fuels and fossil-fuel processing effluents were crossed with a list of key words during a computerized search of six bibliographic data bases. The bibliography contains 1314 citations which are indexed by chemicals, key words, taxonomic categories, and authors. The bibliography is intended especially for researchers working with advanced fossil-fuel processing effluents in aquatic environments, but may also be useful to those concerned with fossil-fuel processing effluents in terrestrial environments and to those working in pulp mill and pesticide research.

McNaught, D. C., M. Buzzard, D. Griesmer, and M. Kennedy. 1980. Zooplankton Grazing and Population Dynamics Relative to Water Quality in Southern Lake Huron. U.S. Environmental Protection Agency, Duluth, Minnesota, Publication No. EPA-600/3-80-069. 143 pp.

Planktonic herbivores controlled the growth of phytoplankton in the open waters of southern Lake Huron during the late summer and fall; larger algae remained untouched during the spring diatom bloom. Over a growing season these crustaceans grazed 0.3 to 41.9% of the standing crop of phytoplankton. Immature copepods (nauplii and copepodites) were the most effective grazers. Selective grazing by crustaceans centered on nanoplankton (<22 μm diameter), whereby 92 to 2804% of the daily productivity was grazed by large cladocerans and immature copepods. In contrast, netplankton was harvested to a much lesser degree. Laboratory experiments reinforced this picture of selective cropping. Presently in Lake Huron such selective grazing accounts for an effective biological control over algal production; such control will be lost if these phytoplankton populations are allowed to shift to ones dominated by large blue-green algae. Populations of herbivores were also used to characterize water quality. Generally outer Saginaw Bay and most inshore waters were of lower water quality than offshore surface waters. These inshore areas also had the highest productivity of zooplankton.

Morden, R. D. 1980. Static Coal Storage--Biological Effects on the Aquatic Environment. U.S. Environmental Protection Agency, Duluth, Minnesota, Publication No. EPA-600/3-80-083c. 25 pp.

Benthic samples taken from four regions of the ORBA Coal dock facility indicated that the aquatic environment was moderately polluted as indicated by the kinds of benthic species present and by the diversity index value. An efficient rearing technique for benthic organisms results in low mortality. The life cycle from hatching to pupal formation in the Chironomus sp. takes 21.9 days at 20.5 C. Stress factors and swimming behavior are also discussed.

Heavy metal concentrations in Helobdella stagnalis were found at all sites during the collecting period. An inventory of benthic organisms present in six regions of the St. Louis River during the spring, summer and fall of 1975 is included.

Natusch, D. F. S., and D. R. Taylor. 1980. Environmental Effects of Western Coal Combustions: Part IV - Chemical and Physical Characteristics of Coal Fly Ash. U.S. Environmental Protection Agency, Duluth, Minnesota, Publication No. EPA-600/3-80-094. 213 pp.

Coal fly ashes from different sources were extensively studied. Fly ash consists of as many as 12 different particle types, made up mainly of Si, Al, Ca, K, Na, and Fe. Many potentially volatile trace elements (As, Se, Ga, In, Pb, Cd) are always preferentially associated with more respirable particles. Many other minor and trace elements may also show an inverse particle size dependence, depending on the coal fly ash. Elements showing no dependence include Al, Ba, Ca, Co, Fe, K, Mg, Rb, Sc, Si, Sr, Ta, Ti, and the rare earths. Most potentially hazardous inorganic species in fly ash can be leached into aqueous solution but are unlikely to give rise to solution concentrations of great concern. The physical and chemical characteristics and behavior of polycyclic models show that adsorption of POM on coal fly ash will occur in seconds in a typical emission stream and that the process is highly temperatue dependent. Surface-adsorbed POM is highly reactive to some nitrogen and sulfur oxides at levels expected to be found in power plant plumes. It was found that some POM adsorbed on fly ash are stabilized against photochemical decomposition, while other compounds decompose readily upon adsorption. Although fly ash emitted to the atmosphere contains much more POM than precipitator ash, there is an insufficient amount to make a discernible impact on any terrestrial aquatic system.

Paul, J. F., A. B. Gorstko, and A. A. Matveyev. 1980. Results of a Joint USA/USSR Hydrodynamic Modeling Project for Lake Baikal. IN: Proceedings of the Second American-Soviet Symposium on the Use of Mathematical Models to Optimize Water Quality Management, Section 8 (W. R. Swain, and V. R. Shannon, eds.), pp. 129-155, U.S. Environmental Protection Agency, Duluth, Minnesota, Publication No. EPA-600/9-80-033.

The work summarized in this paper represents just a preliminary step in a possible comprehensive joint modeling and field study by scientists from our two countries.

It is recommended that a comprehensive joint USA/USSR modeling and field survey program be initiated for a lake such as Lake Baikal. This program would be used to both verify the models and increase the understanding of the processes at work in the lake. Modeling work already underway, along with information available from previous field surveys, would be used to plan an extensive one year field survey. The information that would be available from satellites (for example, LANDSAT and NIMBUS) would be utilized. The usefulness of the satellite imagery to characterize suspended solids in lakes, in conjunction with field data and modeling results, has been demonstrated by Sydor and Oman (1977); Sydor, Stortz, and Swain (1978); and Paul, Mielnik, and Shute (1979). The satellite provides synoptic information on a whole lake basin, while the survey ships provide information at different depths in the lake and can provide ground-truth for the satellite information. Such a program would cover a period of three years: the first year for preparation, the second year for the field surveys, and the third year for the analysis.

Penkal, R. F., and R. W. Gregory. 1980. Environmental Effects of Western Coal Surface Mining. Part VI. Smallmouth Bass and Largemouth Bass in the Tongue River Reservoir, Montana, 1975-76. U.S. Environmental Protection Agency, Duluth, Minnesota, Publication No. EPA-600/3-80-045. 54 pp.

Population parameters of smallmouth bass (Micropterus dolomieui) and largemouth bass (M. salmoides) were studied during 1975 and 1976, before expansion of surface coal mining adjacent to the Tongue River Reservoir in southeastern Montana. Reproductive success, as determined by alongshore seining, varied in different areas of the reservoir and may be correlated to turbidity. Population estimates were obtained at night during spring and fall 1976 with boat electrofishing gear. For yearling and older smallmouth bass the fall population of 13.0 fish/ha and the standing crop of 2.03 kg/ha represented 80 to 84 percent of the totals for basses in the reservoir. The largemouth bass population and standing crop during fall 1976 was 3.2 fish/ha and 0.32 kg/ha. The dominance by smallmouth bass of all year classes for both species except age-1, was attributed to a much higher mortality of under-yearlings among largemouth bass. This higher mortality of largemough bass may be correlated to a lack of shoreline vegetation in the reservoir. Summer mortality of age-2 and older smallmouth bass, estimated from the reduction in numbers of marked fish, was about 40 percent. Smallmouth bass growth and condition were better in the upper than lower end of the reservoir; the difference may be due to forage fish availability. Growth and length-weight relationships were above average for both species when compared with basses in other northern waters, indicating no noticeable effect from nearby surface coal mine operations at the time of the study.

Quigley, E., J. Randall, B. Murray, and A. D'Alessio. 1980. Citizen Concern With Power Plant Siting. Wisconsin Power Plant Impact Study. U.S. Environmental Protection Agency, Duluth, Minnesota, Publication No. EPA-600/3-80-004. 121 pp.

Two hundred and fifteen invited participants attended four public workshops in four Wisconsin cities in the spring of 1977. They were divided into small groups and asked to identify and rank power plant siting concerns in three categories: biological and physical, economic and social, and land use. Each group ranked the top ten concerns in each of the three categories. Participants also completed a survey asking them to rank sites for power plants and transmission lines, to provide some personal background information, and to express their views on the workshop.

A list of every concern mentioned is included in this report, and concerns are combined and analyzed by their ranking, both overall and in the final vote. Economic issues (taxes, consumer costs, community costs, and jobs), agricultural land preservation, and water availability were consistently ranked as the most imporatnt concerns. The survey revealed a negative reaction to siting in residential areas, some preference for several small plants rather than one large one, a favorable reaction to power plants designed to serve only local needs, a negative attitude toward Wisconsin's new tax law which provides less power plant tax money for local governments, and a favorable attitude toward the workshops.

Ragland, K. W., B. D. Goodell, and T. L. Coughlin. 1980. Air Pollution Studies Near a Coal-Fired Power Plant - Wisconsin Power Plant Impact Study. U.S. Environmental Protection Agency, Duluth, Minnesota, Publication No. EPA-600/3-80-048. 114 pp.

Concentrations of dry deposition of sulfur dioxide were investigated near a new 540-MW coal-fired generating station located in a rural area 25 miles north of Madison, Wisconsin. Monitoring data for 2 years before the start-up in July 1975 and for the year 1976 were used to assess the impact of the plume and to investigate the hourly performance of the Gaussian plume model. The Gaussian plume model was successful in predicting annual average concentrations ($r = 0.95$), but inadequate for simulating hourly averages ($r = 0.36$). The incremental annual average increase in ambient SO_2 concentrations within 15 km of the plant was 1-3 $\mu g/m^3$.

Dry deposition of SO_2 was measured within the plume using the gradient transfer method. An annual SO_2 dry deposition flux of 0.5 kg/hectare-year or less within 10 km of the plant was inferred, with is about 3% of the regional background deposition.

Richardson, W. L. 1980. Data Management Requirements for Great Lakes Water Quality Modeling. IN: Proceedings of the Second American-Soviet Symposium on the Use of Mathematical Models to Optimize Water Quality Management, Section 3 (W. R. Swain, and V. R. Shannon, eds.), pp. 37-56, U.S. Environmental Protection Agency, Duluth, Minnesota, Publication No. EPA-600/9-80-033.

An important but often neglected aspect of water quality research and management is data management. Efficient data management is essential to water quality management and research programs. Program managers must recognize the role of data management and make adequate staffing and budget provisions for its implementation. This is the case for whatever purpose to which the data are being applied; however, it is an absolute requirement for timely development of mathematical models.

Models require complete sets of data for all stated variables for the time and space resolution desired. Although the most critical need for modeling is proper surveillance design in the first place, accurate and timely data processing plays a key role in the modeling process. As models become more complex the quantity and complexity of data increases and automated, computerized data base and data analysis tools become more important. As a rule of thumb about 10% of total project costs should be devoted to data management.

Riggs, V. L., and R. W. Gregory. 1980. Environmental Effects of Western Coal Surface Mining. Part V. Age and Growth of Walleyes and Saugers in the Tongue River Reservoir, Montana, 1975-77. U.S Environmental Protection Agency, Duluth, Minnesota, Publication No. EPA-600/3-80-038. 64 pp.

> A study was conducted between 1975-1977 on the population of walleye (Stizostedion vitreum) and sauger (Stizostedion canadense) in the Tongue River Reservoir, in southeastern Montana. The Tongue River Reservoir is the recipient of mine water effluents from the Decker Mine, the largest surface coal mine in the western United States. The objective of the study was to determine possible impacts of the mine on the walleye and sauger populations in the reservoir, and to provide data against which future comparisons can be made. These species were chosen because they are two of the most important game fishes in the reservoir. The age and growth of 640 walleyes and 546 saugers were determined from collections made in gill nets, trap nets, and by electrofishing. The 1973 sauger year class and the 1972 walleye year class dominated the catches during the three years of the study. The movements of tagged fish in late March and early April 1977 strongly suggested that walleyes spawned in the Tongue River, upstream from the reservoir. The growth rates for both species were excellent for a northern latitude reservoir, indicating no noticeable effect by surface coal mine operations at the time of the study.

Robbins, J. A. 1980. Sediments of Southern Lake Huron. Elemental Composition and Accumulation Rates. U.S. Environmental Protection Agency, Duluth, Minnesota, Publication No. EPA-600/3-80-080. 330 pp.

> It is widely recognized that most metal contaminants in lakes are primarily associated with particulate matter and are conveyed to underlying deposits in association with fine-grained materials such as organic debris, hydroxides of iron, and manganese or clay minerals. In the Great Lakes the fine-grained sediments and associated contaminants are not deposited uniformly over the bottom but are confined to "pockets" or depositional basins which are of more limited extent and generally found in deeper areas of each lake. This report describes the composition and rates of accumulation of metal contaminants in the depositional basins of southern Lake Huron.
>
> Results of this study include: (1) recognition of the role of sediment mixing by benthic organisms in modifying metal contaminant and radioactivity profiles, (2) estimates of the rates of accumulation of metal contaminants in these depositional basins, (3) identification of which metals are contaminants and their degree of surface enrichment, and (4) limited comparisons of accumulation rates with lake loadings.

Ross, M. J., and D. B. Siniff. 1980. Spatial Distribution and Temperature Selection of Fish Near the Thermal Outfall of a Power Plant During Fall, Winter and Spring. U.S. Environmental Protection Agency, Duluth, Minnesota, Publication No. EPA-600/3-80-009. 129 pp.

> The movement patterns of 4 fish species; yellow perch (*Perca flavescens*), northern pike (*Esox lucius*), largemouth bass (*Micropterus salmoides*) and walleye (*Stizostedion vitreum*) were monitored by radio telemetry near the thermal discharge of a power plant (Δ T 15 C nominal). Fish movements relative to depth, temperature, center of the home range, discharge point, and release location were examined. Near thermally altered areas, northern pike exhibited the greatest amount of movement followed by yellow perch, walleye and largemouth bass. Except for largemouth bass, thermal experience was found to be transitory. An overall mean winter temperature selection of 5.4 C was determined for yellow perch. While only in the thermally altered area yellow perch had a slightly higher mean thermal experience, 6.3 C. Yellow perch were not found to be attracted from the surrounding areas into the heated waters of the discharge bay during the cooler months. Not until spring was a population concentrating influence observed and that was believed due to indirect influences; more cover due to greater available light in the ice free area contributing to a higher standing stock of aquatic vegetation.
>
> We concluded that temperature, when in concert with numerous other environmental variables, did not alter the distribution of yellow perch to that predicted on the basis of laboratory temperature preference studies. Furthermore, movement patterns of northern pike, walleye and largemouth bass were found to be relatively similar to those reported from thermally unaltered areas.

Russo, R. C. 1980. Recent Advances in the Study of Nitrite Toxicity to Fishes. IN: Proceedings of the Third USA-USSR Symposium on the Effects of Pollutants Upon Aquatic Ecosystems, Section 16 (W. R. Swain, and V. R. Shannon, eds.), pp. 226-240, U.S. Environmental Protection Agency, Duluth, Minnesota, Publication No. EPA-600/9-80-034.

> This report reviews recent literature on nitrite toxicity to aquatic organisms. Topics addressed include work on the effects of water chemistry variables on nitrite toxicity, mechanism of toxic action of nitrite, and new toxicity data for several fish species.

Russom, C. 1980. Freshwater Findings, 1976-1978. Research Publications of the Environmental Research Laboratory, Duluth, Minnesota, U.S. Environmental Protection Agency, Duluth, Minnesota, Publication No. EPA-600/9/80-007. 66 pp.

This bibliography, inclusive from 1976 through 1978 lists all publications authored by personnel of the Environmental Research Laboratory-Duluth. Not only does the bibliography list all scientific materials (journal articles, research reports, and other) published by the laboratory staff, but also those project reports prepared by universities, industries, and other government researchers conducting studies under the funding and direction of this laboratory.

The publications are grouped in two sections---reports published in EPA's (and precursor agencys') research series, and journal arcticles from the scientific literature. Each category is subdivided by year and is annotated. Within each year, publications are listed alphabetically by the senior author's last name, and source of reprints are identified. Introductory materials include a list of standard abbreviations for scientific journals cited and pertinent components of the EPA and the laboratory. The bibliography concludes with an author and key word index for all entries.

Sanders, H. O. 1980. Sublethal Effects of Toxaphene on Daphnids, Scuds, and Midges. U.S. Environmental Protection Agency, Duluth, Minnesota, Publication No. EPA-600/3-80-006. 24 pp.

Daphnids (Daphnia magna), scuds (Gammarus pseudolimnaeus), and midge larvae (Chironomus plumosus) were continuously exposed to toxaphene in a flow-through system. Exposure of daphnids for a complete life cycle (21 days) to 0.12, 0.28, 0.54, and 1.0 µg/l of toxaphene significantly ($P<0.05$) reduced production of young; the no-effect concentration was 0.07 µg/l. Toxaphene concentrations of 0.25 µg/l and greater significantly ($P<0.05$) reduced growth of scuds and concentrations of 3.2 µg/l and greater significantly ($P<0.05$) reduced emergence of midges. The no-effect concentrations were 0.13 µg/l for growth of scuds and 1.0 µg/l for emergence of midges. Daphnids continuously exposed to toxaphene accumulated residues after 7 days that were 4,000 times (based on organism wet weight) the water concentration of 0.06 µg/l. Whole body residues in midge larvae were below the minimum detection limit of 0.1 µg/g. Maximum acceptable toxicant concentrations (MATC) of toxaphene for the three species of aquatic invertebrates were estimated using reproduction of daphnids, growth of scuds, and emergence of midges as indicators of toxic effects. The MATC was estimated to be between 0.07 and 0.12 µg/l for daphnids, between 0.13 and 0.25 µg/l for scuds, and between 1.0 and 3.2 µg/l for midges.

Schelske, C. L., R. A. Moll, and M. S. Simmons. 1980. Limnological Conditions in Southern Lake Huron, 1974 and 1975. U.S. Environmental Protection Agency, Duluth, Minnesota, Publication No. EPA-600/3-80-074. 189 pp.

In 1974 and 1975, several studies were conducted on southern Lake Huron and outer Saginaw Bay to obtain seasonal data on limnological conditions. In 1974, 44 stations were sampled on each of eight cruises conducted from April to November. Each station was sampled at multiple depths so that more than 200 samples were taken on each cruise. Data obtained for each sample included water temperature, pH, specific conductance, chloride, total phosphorus, soluble reactive silica, nitrate plus nitrite nitrogen, ammonia nitrogen, chlorophyll a, and phaeopigments. In 1975, five special cruises were conducted. Four of these were used to compare phytoplankton productivity and nutrient dynamics in the frontal zone between highly enriched Saginaw Bay and the relatively low productivity waters of southern Lake Huron. One cruise was used to study the effect of the spring thermal bar on the distribution of nutrients and nearshore phytoplankton standing crops. These studies confirm that Saginaw Bay and the nearshore zone of southern Lake Huron have larger concentrations of total phosphorus (the major growth limiting nutrient in the system) and greater standing crops of phytoplankton than the offshore waters. They also show that the nearshore zones, especially on the Canadian shore, differ from the offshore waters to a greater degree during the period of the spring thermal bar than at other times of the year.

Shaver, M. P., and P. Page. 1980. Local Land-Use and Landownership Patterns Near a Power Plant-Wisconsin Power Plant Impact Study. U.S. Environmental Protection Agency, Duluth, Minnesota, Publication No. EPA/600-3-80-021. 68 pp.

As a result of the construction of the Columbia Generating Station (Columbia I) near Portage, Wisconsin, the three sponsoring utility companies began making compensation payments in 1971 to the host township, Pacific Township, Columbia County. As specified by Wisconsin statutes, these payments are designed to compensate the township for property tax losses caused by the plant, for possible increased costs for social services, and for possible increased environmental degradation. Despite recent amendments to the statutes, these payments have created a "tax island" in Pacific Township; that is, the township no longer needs to levy any local property tax.

Property records and land-use maps indicate that by 1975 residential development had accelerated in the township, although no significant increase in commerical or industrial development was evident. The sharp upturn in the rate of residential growth contrasted with a continuous and moderate rate of growth in the adjacent township of Fort Winnebago. The change in Pacific Township was accompanied by decreases in the average size of individual property holdings and in the average size of individual property sales. No signficant change was found in the proportion of absentee or corporate owners in the township.

These findings must be considered preliminary, since they are based only on the 4 years following the beginning of construction of the station, and since other factors may have contributed to the observed changes.

Sheng, Y. P., and W. Lick. 1980. A Two-Mode Free-Surface Numerical Model for the Three-Dimensional Time-Dependent Currents in Large Lakes. U.S. Environmental Protection Agency, Duluth, Minnesota, Publication No. EPA-600/3-80-047. 70 pp.

> A two-mode, free-surface model based on vertically-stretched coordinates and a vertically-implicit scheme has been developed and applied to Lake Erie under non-stratified conditions. A brief description of the general equations and boundary conditions is given first. The detailed equations for a two-mode, free-surface model are then described. Finite-difference procedures including the finite - difference equations are listed in detail. The model is first applied to idealized basins and then to Lake Erie for two wind conditions; (1) a uniform wind suddenly imposed, and (2) an actual wind variable in both space and time. The results of the computations are compared with the resutls from a single-mode, free-surface model and from a rigid-lid model.

Skogerboe, R. K., Miller, M. M., D. L. Dick, R. V. Thurston, and R. C. Russo. 1980. Environmental Effects of Western Coal Combustion. Part III. The Water Quality of Rosebud Creek, Montana. U.S. Environmental Protection Agency, Duluth, Minnesota, Publication No. EPA-600/3-80-071. 68 pp.

> The results of a study on Rosebud Creek, Montana, designed to assess the impacts on water quality of surface coal mining and/or coal combustion at Colstrip are summarized. A general degradation of water quality has been observed along the stream course but direct impacts of groundwater from the mine areas have not been demonstrated. Influxes of arsenic, mercury, selenium, and polynuclear aromatic compounds during snowmelt periods have been linked by analyses of snow samples to their accumulation in snowfall via scavenging of the power plant plume and subsequent delivery to the stream via surface runoff. Although this contaminant transfer route may prove highly significant, it is emphasized that this will depend on site specific conditions.

Stoermer, E. F. 1980. Characteristics of Benthic Algal Communities in the Upper Great Lakes. U.S. Environmental Protection Agency, Duluth, Minnesota, Publication No. EPA/600-3-80-073. 79 pp.

> The upper Great Lakes contain a diverse array of benthic algal communities. Characteristic communities occupy substrates from the supralittoral to depths in excess of 30 m. Diatoms are the dominant taxonomic group present in terms of numbers, and usually in terms of biomass, except in eutrophic areas. Communities in areas receiving minimal direct anthropogenic impact are extremely diverse in terms of both species richness and population evenness. The populations which comprise these communities are generally reported from extremely oligotrophic habitats. A significant number of populations found in undisturbed habitats in the upper Great Lakes have been previously

reported from North America. Benthic communities in more eutrophic areas are characterized by a greater abundance of eurytopic and widely distributed taxa. Many of these species are familiar elements of the floras of smaller, mesotrophic to eutrophic lakes. The communities of directly affected areas contain a more limited suite of very tolerant populations, usually occurring in high abundance.

Stoermer, E. F., and R. G. Kreis, Jr. 1980. Phytoplankton Composition and Abundance in Southern Lake Huron. U.S. Environmental Protection Agency, Duluth, Minnesota, Publication No. EPA-600/3-80-061. 396 pp.

Southern Lake Huron contains a diversity of phytoplankton assemblage types ranging from assemblages characteristic of oligotrophic waters to those which usually occur under highly eutrophic conditions. The offshore waters are generally characterized by oligotrophic associations and most eutrophic associations are associated with the Saginaw Bay interface waters. Under certain conditions, populations which are generated within Saginaw Bay are found mixed with offshore assemblages, apparently as a result of passive dispersal. The most widely dispersed populations include nuisance-producing blue-green algae such as Aphanizomenon flos-aquae. During the period of study, floristic modification resulting from inputs from Saginaw Bay was usually found along the Michigan coast south of the bay, but cases were noted where greatest effect was found at stations north of the bay or eastward into the open lake. Along the Canadian shore assemblages were qualitatively and quantitatively dissimilar from assemblages in Saginaw Bay. On the basis of our results southern Lake Huron appears to be a somewhat more disturbed region than generally realized. Phytoplankton assemblage modification appears to result from both the influence of nutrients and other materials entering the lake directly and from the dispersal of populations from highly eutrophic Saginaw Bay into the open lake. The wide dispersal of these populations is of special interest since it may furnish a mechanism for transport of nutrients and toxic material from highly impacted Saginaw Bay into the open lake.

Stoermer, E. F., L. Sicko-Goad, and D. Lazinsky. 1980. Synergistic Effects of Phosphorus and Heavy Metal Loadings on Great Lakes Phytoplankton. IN: Proceedings of the Third USA-USSR Symposium on the Effects of Pollutants Upon Aquatic Ecosystems, Section 13 (W. R. Swain, and V. R. Shannon, eds.), pp. 171-186, U.S. Environmental Protection Agency, Duluth, Minnesota, Publication No. EPA-600/9-80-034.

In this report we attempt to address some of the interactive effects of two types of contaminant loadings, phosphorus and heavy metals, which might not be discerned by conventional limnological methods. The research was originally initiated in an attempt to explain the apparent differential influence of phosphorus enrichment on particular species of phytoplankton advected through zones of phosphorus pollution. Loadings, biological availability, and biological pathways of this nuitrient in the Great Lakes system are of particular interest because it is the primary nutrient controlling eutrophication. Most undesirable anthropogenic modifications of the Great Lakes ecosystem are directly related to increased phosphorus loadings resulting from increased population densities, introduction and widespread usage of phosphorus containing detergents, and poor land management practices. In the course of this investigation we found that the mechanism allowing differential sequestering of phosphorus was intimately associated with heavy metal concentration in the water and that the same mechanism could permit excessive uptake of certain toxic metals. Since this bioaccumulation mechanism could have both effects on the aquatic ecosystem and potential effects on human health we have attempted to determine some of the factors involved.

Swain, W. R., and V. R. Shannon (eds). 1980. Proceedings of the Second American-Soviet Symposium on the Use of Mathematical Models to Optimize Water Quality Management. U.S. Environmental Protection Agency, Duluth, Minnesota, Publication No. EPA-600/9-80-033. 410 pp.

The Joint US-USSR Agreement on Cooperation in the Field of Environmental Protection was established in May of 1972. These proceedings result from one of the projects, Project 02.02-12, Effects of Pollutants on Lakes and Estuaries.

As knowledge related to fate and transport of pollutants has grown, it has become increasingly apparent that local and even national appraoches to solving pollution problems are insufficient. Not only are the problems themselves frequently international, but an understanding of alternate methodological approaches to the problem can avoid needless duplication of efforts. This expansion of interest from local and national framework represents a logical and natural maturation from the provincial to a global concern for the environment.

In general, mankind is faced with very similar environmental problems regardless of the national or political boundaries which we have erected. While the problems may vary slightly in type or degree, the fundamental and underlying factors are remarkably similar. It is not surprising, therefore, that the interests and concerns of environmental scientists the world over are also quite similar. In this larger sense, we are our brother's brother, and have the ability to understand our fellowman and his dilemma, if we but take the trouble to do so. It is this singular idea of concerned scientists exchanging views with colleagues that provides the basic strength for this project.

Swain, W. R., and V. R. Shannon (eds.). 1980. Proceedings of the Third USA-USSR Symposium on the Effects of Pollutants Upon Aquatic Ecosystems: Theoretical Aspects of Aquatic Toxicology. U.S. Environmental Protection Agency, Duluth, Minnesota, Publication No. EPA-600/9-80-034. 259 pp.

The Joint US-USSR Agreement on Cooperation in the Field of Environmental Protection was established in May of 1972. These proceedings result from one of the projects, Project 02.02-13, Effects of Pollutants Upon Aquatic Ecosystems and Permissible Levels of Pollution.

As knowledge related to fate and transport of pollutants has grown, it has become increasingly apparent that local and even national approaches to solving pollution problems are insufficient. Not only are the problems themselves frequently international, but an understanding of alternate methodological approaches to the problem can avoid needless duplicaton of efforts. This expansion of interest from local and national framework represents a logical and natural maturation from the provincial to a global concern for the environment.

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Sydor, M., and K. Stortz. 1980. Sources and Transports of Coal in the Duluth-Superior Harbor. U.S. Environmental Protection Agency, Duluth, Minnesota, Publication No. EPA-600/3-80-007. 94 pp.

Dispersion of particulates from an ORTRAN coal transshipment facility was investigated to estimate the input of coal dust into the Duluth harbor and to determine the transport of coal particulates to Lake Superior. A numerical model was used to discuss dispersal of contaminants and determine the residence time of pollutants in the water way. The model was verified using measurements of water levels, current and water quality parameters.

Sydor, M., G. E. Glass, and W. R. Swain. 1980. Transport of Mining Waste in Lake Superior. IN: Proceedings of the Second American-Soviet Symposium on the Usage of Mathematical Models to Optimize Water Quality Management, Section 10 (W. R. Swain, and V. R. Shannon, eds.), pp. 180-196, U.S. Environmental Protection Agency, Duluth, Minnesota, Publication No. EPA-600/9-80-033.

Transport of iron ore tailings in western Lake Superior has been the subject of considerable local interest and general interest regarding dispersion of contaminants in the Great Lakes. The transport of particulates can be investigated through use of remote sensing and numerical modeling. Fine particulates in lakes are identifiable through use of Landsat data. Their remote sensing signatures provide valuable information for studies of the dispersal processes and verification of numerical models. We consider here measurements and remote sensing data which suggest transport of tailings by means of an upwelling. Two wind episodes are discussed in detail. In one instance transports and dispersal of a plume is simulated numerically for the actual wind and pressure conditions over the lake. The model results are subsequently compared with measurements of suspended solids and the remote sensing data for the plume. The results show that the direct transport of tailings cannot readily account for the episodes of high concentration of tailings at the Duluth water intake. In the instance chosen as our second example, Landsat images for two consecutive days show discrete high concentration patches of tailings which appear to have upwelled during westerly winds. The successive images and current measurements at two stations show that tailings patches are transported in accordance with the results from numerical models. The patches appear to have originated from an upwelling near the Duluth water intake. The data for the intake show that the concentration of tailings in the patches exceeded 3 mg/1, a level which is an order of magnitude higher than the concentrations produced by the direct transport of turbidity to Duluth.

Tanis, F. J. 1980. A Remote Sensing Technique to Monitor Cladophora in the Great Lakes. U.S. Environmental Protection Agency, Duluth, Minnesota, Publication No. EPA-600/3-80-075. 36 pp.

The feasibility of using an airborne multispectral scanner to monitor shoreline algae problems has been demonstrated. Multispectral data were collected at two sites on the U.S. Lake Ontario shoreline. Computer generated color maps were produced to show spatial distribution of Cladophora in the nearshore zone and to estimate standing crop.

Ground truth data as a unit samples of bottom vegetation were collected at several locations which were marked in the imagery by surface floats.

A depth invariant model based upon principal component anlaysis was used to process seven passive bands between 0.46 and 0.70 micrometers. Spectral features of Cladophora were related to measured standing crop.

Tetrick, N., and E. Joeres. 1980. Water Constraints in Power-Plant Siting and Operation. Wisconsin Power Plant Impact Study. U.S. Environmental Protection Agency, Duluth, Minnesota, Publication No. EPA-600/3-80-077. 127 pp.

A conceptual study of water quality in the Wisconsin River between Wisconsin Dells and Lake Wisconsin was performed to determine the range of choices that might be available for determing the trade-off between organic waste discharges and heat assimilation from possible power plant sites. The QUAL-3 river quality model, as modified by the Wisconsin Department of Natural Resources for use on the upper Wisconsin and lower Fox Rivers, was used for preliminary simulations of the effect of potential heat discharges from three possible power plant sites on the levels of dissolved oxygen, biochemical oxygen demand, and algae growth during times of extremely low flow. Hydraulic parameters for the QUAL-3 model were estimated from simulations employing the Army Corps of Engineers' HEC-2 water surface profile model. Estimates of river temperature downstream of heat discharges were obtained using a simple one-dimensional river temperaure model developed by Paily and Macagno (1976). Results of simulations at various levels and locations of heat discharges are presented in the presence and absence of discharge at the Portage Wastewater Treatment Plant effluent into the Wisconsin River, and of concerted control of point and non-point sources of nutrients in and upstream of the regional study. The results suggest that the levels of dissolved oxygen in Lake Wisconsin would be most sensitive to nutrient levels in the Wisconsin River and that elevated nutrient levels resulting from heat discharges could cause greater drops in the dissolved oxygen levels in the lake.

Thurston, R. V. 1980. Some Factors Affecting the Toxicity of Ammonia to Fishes. IN: Proceedings of the Third USA-USSR Symposium on the Effects of Pollutants Upon Aquatic Ecosystems, Section 10 (W. R. Swain, and V. R. Shannon, eds.), pp. 118-137, U.S. Environmental Protection Agency, Publication No. EPA-600/9-80-034.

The effects of several chemical and biological factors on the toxicity of un-ionized ammonia to fishes are discussed. These include prior acclimation of fish to sublethal ammonia concentrations, water temperature, dissolved oxygen concentration, and pH. Implications of these effects in relation to water quality criteria for ammonia are discussed.

Zeveloff, L. B., M. Parker, M. D. Marcus, and H. L. Bergman. 1980. Volume 2: Bibliography of Aquatic Ecosystem Effects, Analytical Methods and Treatment Technologies for Organic Compounds in Advanced Fossil-Fuel Processing Effluents. U.S. Environmental Protection Agency, Duluth, Minnesota, Publication No. EPA-600/3-80-086. 222 pp.

Advanced fossil-fuel processing operations, including oil-shale retorting, coal gasification, coal liquifaction and tar-sands recovery, can result in chemically complex aqueous waste effluents. This bibliography compiles much of the recent literature (including 1979) concerning effects of organic compounds in advanced fossil-fuel processing effluents when discharged into aquatic ecosystems, plus information available on analytical methods and treatment technologies for these organics. To compile the bibliography, nearly 500 organic compounds known to be constituents of fossil-fuels and fossil-fuel processing effluents were crossed with a list of key words during a computerized search. The bibliography contains 1135 citations which are indexed by chemicals, key words, taxonomic categories and authors.

1981

JOURNAL ARTICLES, BOOK CHAPTERS, PROCEEDINGS, ETC.

Albuyeh, F., and J. J. Skiles. 1981. A Transmission Network Planning Method for Comparative Studies. IEEE Transactions on Power Apparatus and Systems, PAS-100(4): 1679-1684.

> An automated transmission network planning method for comparative studies is presented. This method employs logical steps that may closely parallel those taken in practice by the planning engineers. Use is made of a sensitivity matrix to simulate the engineers' experience in selecting the contingency cases to be studied and for the selection of branches to be reinforced. The network is expanded to satisfy a given reliability criterion over the planning period. A representative example showing the application of this method to the IEEE 14 Bus Test System is presented.

Baker, J. R., and T. F. Jordan. 1981. Vertical Structure of Time-Dependent Flow for Viscosity that Depends on Both Depth and Time. J. Physical Oceanogr. 11(12): 1673-1674.

> A previously developed eigenfunction expansion, that describes horizontal current as a function of depth and time, is extended to include an eddy viscosity given as a product of a function of depth and a function of time.

Batterman, A. R., and P. M. Cook. 1981. Determination of Mineral Fiber Concentrations in Fish Tissues. Can. J. Fish. Aquat. Sci. 38(8): 952-959. ERL-D Reprint #254.

> Submicroscopic inorganic particle concentrations in tissue have not been quantitatively determined in the past because of a lack of sample preparation techniques capable of achieving the sensitivity required. The determination of whether mineral fibers in water are accumulated in aquatic organisms requires transmission electron microscope examination of bulk tissue residues rather than thin sections. The sample preparation method used for this investigation involved removal of water and organic matter by freeze-drying and low temperature ashing. Lake trout with a lifetime exposure to Lake Superior water containing amphibole fibers contained similar amphibole fibers particularly in the kidney and with low concentrations in muscle tissue. Lake trout from two locations with widely different water fiber concentrations had corresponding differences in tissue fiber concentrations. Analysis of other fish raised under laboratory conditions suggests that ingestion is the primary route for fiber accumulation.

Bierman, V. J., Jr., and D. M. Dolan. 1981. Modeling of Phytoplankton-Nutrient Dynamics in Saginaw Bay, Lake Huron. J. Great Lakes Res. 7(4): 409-439. ERL-D Reprint #296.

A multi-class, phytoplankton simulation model was developed and calibrated to an extensive set of field data acquired on Saginaw Bay, Lake Huron, during 1974. Phytoplankton biomass was partitioned into five functional groups: diatoms, greens, non-N_2-fixing blue-greens, N_2-fixing blue-greens, and "others". Nutrients included in the model were phosphorous, nitrogen, and silicon. The model was applied to a single spatial segment encompassing the inner portion of Saginaw Bay.

Process level analyses were conducted with the calibrated model to determine the relative importance of various factors affecting phytoplankton and nutrient dynamics. The concept of a single limiting factor for phytoplankton growth was found to be overly simplistic. Results indicated that temperature and light were relatively more growth rate limiting than nutrients on an annual average basis. However, as a consequence of nutrient depletion, nutrients became relatively more important at the times of peak phytoplankton crops. Nitrogen was found to be relatively more growth rate limiting than phosphorus to the total phytoplankton crop, although important differences occurred among the individual functional groups. At various times, and for various groups, all three nutrients were important in limiting either the rates of growth and/or the maximum sizes of the phytoplankton crops. Results were consistent with the hypothesis that while nitrogen and silicon were important in phytoplankton-nutrient dynamics, the supply of phosphorus would ultimately determine the size of the blue-green component of the total crop because N_2-fixing blue-greens do not have absolute requirements for dissolved available nitrogen or silicon. Results indicated that phosphorus requirements of spring and fall diatom crops were satisfied primarily by external loadings. Phosphorus requirements of summer blue-green crops were satisfied primarily by recycle processes within the water column. Upon cell death, direct nutrient recycle to the available nutrient compartments in the water column from excess internal phytoplankton stores was found to be important for both phosphorus and nitrogen. Phytoplankton production was found to be extremely sensitive to variations in the light extinction coefficient in the water column, and relatively insensitive to variations in incident solar radiation.

Boling, R. H., Jr. 1981. A Technique for Computer-Controlled Toxicant Injection. Bull. Environ. Contam. Toxicol. 27: 773-774.

A technique has been devised to accurately inject relatively large quantities of a toxic compound into an experimental aquatic system for toxic stress experiments. This technique has proven superior to the more conventional methods of injecting the toxicant dissolved in a solvent or in an aqueous solution near saturation. In addition to the large volumetric delivery capability, it was desired to control the injection rate by an on-line monitoring and control computer system. The resulting design resolves the difficulties of:

1. test compounds exhibiting low-solubility in water;
2. highly volatile compounds;
3. rapidly biodegradable compounds;
4. compounds with a high melting point; and
5. accurately preparing and maintaining large quantities of known-concentration solutes.

Breger, R. K., R. B. Franklin, and J. J. Lech. 1981. Metabolism of 2-Methylnaphthalene to Isomeric Dihydrodiols by Hepatic Microsomes of Rat and Rainbow Trout. Drug Metab. Dispos. 9(2): 88-93.

> The metabolism of 2-methylnaphthalene in rats (*in vivo* and *in vitro*) and rainbow trout (*in vitro*) has been investigated. Three isomeric dihydrodiols were formed by microsomal preparations and these were isolated and identified by high-pressure liquid chromatography and gas chromatography/mass spectroscopy. The temperature, microsomal protein content, and incubation time were varied to obtain the optimum conditions for their formation. The conversion of 2-methylnaphthalene to both monohydroxylated compounds and dihydrodiols was reduced by incubation with carbon monoxide, the omission of NADPH, or use of heat-denatured microsomes, implying the involvement of cytochrome(s) P-450-linked mixed-function oxidase activity. The three dihydrodiols obtained *in vitro* in microsomes from both rat and fish were identical with those compounds isolated from rat urine. Pretreatment with phenobarbital and β-naphthoflavone selectively altered the rate of formation of specific dihydrodiols by rat liver microsomes. Although phenobarbital had no significant effect on the rate of dihydrodiol formation in trout liver microsomes, β-naphthoflavone was a strong inducer and its selectivity in increasing the rate of dihydrodiol formation was similar to that seen with rat liver microsomes.

Broderius, S. J. 1981. Determination of Hydrocyanic Acid and Free Cyanide in Aqueous Solution. Anal. Chem. 53(9): 1472-1477. ERL-D Reprint #256.

> Microgram-per-liter concentrations of HCN in aqueous solutions were determined directly by two methods: bubbling compressed air through a solution to displace a small quantity of HCN, which was collected in a glass bead concentration column, or allowing some HCN to diffuse from an enclosed solution into dilute NaOH in a dish suspended above the solution. The separated and concentrated cyanide was determined colorimetrically. The HCN concentration was calculated from linear calibration curves that related the determined HCN displacement rate or quantity of HCN collected to the known concentration of HCN for standard cyanide solutions. The linear relationship between pK for HCN (aq) and 1/temperature in degrees Kelvin was defined. Thus the fraction of free

cyanide (i.e., HCN + CN$^-$) as HCN for specific conditions of temperature and pH could be determined. These procedures for determining HCN in various waters and wastewaters were accurate, precise, and not susceptible to common interfering substances.

Canton, S. P., and J. V. Ward. 1981. Emergence of Trichoptera from Trout Creek, Colorado, USA. IN: Proc. of the 3rd Int. Symp. on Trichoptera, Series Entomologica, Vol. 20, (G. P. Moretti, ed.), pp. 39-45, Dr. W. Junk Publ., The Hague.

A total of 21 species of adult Trichoptera were collected over two years with black-light trap and sweep-net from a site on Trout Creek, a mountain stream in northwestern Colorado. The adult flight period was from mid-June to early October. A total of 7863 organisms were collected over the two years representing 8 families, 16 genera, and 21 species. Two species (*Lepidostoma moneka* and *Brachycentrus americanus*) accounted for 81% of the total numbers of adults. Seasonal emergence patterns exhibited three peaks in both numbers of adults and numbers of species collected. The early summer group (mid-June to mid-July) was represented by 4 species comprising 5% of total numbers. The mid-summer group (mid-July to mid-August) of 10 species accounted for 90% of total numbers. The late summer-early fall group (mid-August to early October) of 7 species comprised 5% of the total numbers of adults. Three species (*L. moneka*, *Wormaldia gabriella*, *Neotrichia okapa*) are new records for Colorado. Sex ratios for abundant species ranged from 34% females (*B. americanus*) to over 65% females (*Glossosoma ventrale*). Season appeared to have no effect on sex ratios.

Canton, S. P., and J. V. Ward. 1981. The Aquatic Insects, with Emphasis on Trichoptera, of a Colorado Stream Affected by Coal Strip-Mine Drainage. Southwest. Nat. 25(4): 453-460.

Benthic sampling was conducted year-round over a 2 year period (July 1975-June 1977) on Trout Creek, a mountain stream in northwestern Colorado, to assess the effects of coal mine drainage on the stream insect community. Samples were taken monthly from rubble riffles above and below drainage from unreclaimed mine spoils. Unexpectedly, aquatic insects exhibited similar mean density and biomass values at each site and accounted for at least 95% of the total benthic standing crop above and below the mine. The number of insect taxa was similar and diversity index values did not vary significantly between sites. However, the community structure of the two sites did differ. Certain taxa were most abundant at the upstream site (*Prostoia besametsa* and *Lepidostoma moneka*), while others were more abundant at the downstream location (*Agapetus boulderensis*, *Glossosoma ventrale*, and *Hydropsyche* spp.). The greatest difference between the two sites was the differential importance of Trichoptera. At the upper site, caddisflies accounted for 39% of the benthic density due to the abundance of four families

(Lepidostomatidae, Glossosomatidae, Brachycentridae, and Hydroptilidae). Trichopterans acounted for 60% of the benthic density below the mine, due primarily to the abundance of Hydropsychidae, and especially Glossosomatidae. This study points to the importance of community structure analysis in assessing effects of changes in environmental conditions in stream systems.

Christensen, G. M., and D. L. Olson. 1981. Effect of Water Pollutants and Other Chemicals Upon Ribonuclease Activity in vitro. Environ. Res. 26: 274-280. ERL-D Reprint #260.

Ribonuclease was treated in vitro with 73 chemicals, many of which are environmental pollutants, including inorganic, organic, and metal-organic chemicals, pesticides and other biocides, alkyl and aryl industrial pollutants, and certain additional chemicals, to determine their effect upon enzyme activity. Palladium (II and IV) and gold (III) were the strongest inhibitors of RNase activity. Other strong inhibitors, in decreasing order of effect, were: sodium dodecyl sulfate, silver (I), EDTA, mercury (II), copper (II), thiram (fungicide), platinum (IV), malathion (pesticide), lead (II), and beryllium (II). Intermediate effects were found with other inorganic cations, many anions, and some other chemicals. A number of compounds of different chemical types caused no measurable effect. None of the chemicals tested caused a measurable activation of this enzyme.

Christensen, G. M., and B. Riedel. 1981. Effects of Water Pollutants and Other Chemicals Upon the Activity of Lipase in vitro. Arch. Environm. Contam. Toxicol. 10: 357-363. ERL-D Reprint #243.

Lipase preparations were treated in vitro with 100 chemicals of various classes, many of which are environmental pollutants, to determine their effect upon enzyme activity. The greatest inhibition was caused by mercuric ion and certain heavy metal cations; almost as inhibiting were pentachlorophenol, dicofol, 2,4,5-trichlorophenol, and DDT. Less inhibition was found with other inorganic salts, organo-metals, other organic chemicals, and some pesticides. Apart from dichromate ion, the anions studied had a low to negligible effect on lipase. A mixture of 10 inorganic salts had an approximately cumulative inhibitory effect on enzyme activity. None of the chemicals studied caused a measurable activation of the enzyme.

Cook, P. M., and D. L. Longrie. 1981. Determination of Asbestos and Other Inorganic Particle Concentrations in Urine. IN: Electron Microscopy and X-ray Applications to Environmental and Occupational Health Analysis, Volume 2 (P. A. Russel, ed.), pp. 219-231, Ann Arbor Science Publishers. ERL-D Reprint #250.

Until recently there was no direct evidence for the passage of microscopic inorganic particles, particularly mineral fibers, through the human gastrointestinal mucosa following ingestion. However, rodents fed chrysotile asbestos or latex particles were found to have these particles accumulated in various tissues. The potential for asbestos fibers to be retained in extrapulmonary tissues following ingestion must be evaluated in order to understand if the observed excess mortality due to gastrointestinal and peritoneal cancer among populations occupationally exposed to asbestos dust is the result of ingestion of asbestos, either directly or following mucociliary clearance of inhaled fibers from the respiratory tract. Definite evidence for mineral fiber penetration of the human gastrointestinal tract can be provided by the measurement of specific fibers in tissue or body fluids of persons who ingested the mineral fibers with food or drinking water without inhalation exposure.

Attempts to analyze human extrapulmonary tissues for mineral fibers by electron microscopy have been generally unsuccessful for a number of technical reasons. Sample preparation techniques used often do not provide sufficient sensitivity to allow detection of fiber concentrations likely to be present. Auerback examined lung tissue by optical microscopy for asbestos bodies. They did not observe a greater number of asbestos bodies for individuals who ingested amphibole fiber contaminated drinking water than for residents of a city with few fibers in its drinking water. Ingested large mineral fibers transported to the lung after passing through the gastrointestinal mucosa are unlikely to be numerous enough to provide a noticeable excess of asbestos bodies.

The daily production of urine represents several hundred passes of the body's blood through the kidneys. Therefore, electron microscope examination of particles isolated from urine of persons regularly ingesting mineral fibers might allow the detection of such fibers. Optical microscope observation of 4-6 m long asbestos fibers in the urine of asbestos workers has been reported. These fibers were proposed to exist in urine by transport of inhaled fibers through the alveolar wall to the circulatory system but could also have passed through the gastrointestinal tract to the blood following clearance from the lung.

Urine samples from individuals ingesting amphibole fibers in drinking water have now been found to contain these fibers. No amphibole fibers are found in the urine of individuals with no history of exposure to amphibole fibers. Cessation of ingestion exposure results in non-detectable amphibole fiber concentrations in the urine within one year. The fibers transported to urine have a shorter distribution of lengths than fibers in the drinking water. This implies that shorter fibers are more easily transported through the gastrotrointestinal mucosa, other tissues, the circulatory system and finally the kidneys. The transport of ingested mineral fibers to urine was also recently observed for a juvenile baboon following oral gavage administration of chrysotile. As with humans the shorter fibers tend to be eliminated in the baboon urine.

Cooper, C. L., W. C. Bartholomew, C. E. Herdendorf, J. M. Reutter, and F. L. Snyder. 1981. Limnetic Larval Fish of the Maumee and Sandusky River Estuaries. J. Great Lakes Res. 7(1): 51-54.

> A total of 17 taxa were collected in the Maumee River estuary during sampling periods in 1975, 1976, and 1977. A total of 11 taxa were collected from the Sandusky River estuary in 1976. Gizzard shad/alewife, *Dorosoma cepedianum*/*Alosa pseudoharengus*, white bass/white perch, *Morone chrysops*/*Morone americana*, and freshwater drum, *Aplodinotus grunniens*, constituted 98% of the larvae collected in the Maumee River estuary proper and 91% of the larvae collected in the Sandusky River estuary. Capture, relative abundance, and average density data for each taxon collected are summarized.

Cooper, C. L., M. R. Heniken, and C. E. Herdendorf. 1981. Limnetic Larval Fish in the Ohio Portion of the Western Basin of Lake Erie, 1975-1976. J. Great Lakes Res. 7(3): 326-329.

> A total of 19 taxa of larval fish was collected with metered plankton nets in Ohio and adjacent Ontario waters of the western basin of Lake Erie. Analysis of yellow perch, *Perca flavescens*, collection data indicates that shallow inshore areas serve as important nursery areas for this species. Collection of larvae provides evidence of relic breeding populations of lake whitefish, *Coregonus clupeaformis*, and sculpin (*Cottus* sp.) in the western basin.

DePinto, J. V., T. C. Young, and S. C. Martin. 1981. Algal-Available Phosphorus in Suspended Sediments from Lower Great Lakes Tributaries. J. Great Lakes Res. 7(3): 311-325.

> Suspended sediments collected from five tributaries to the lower Great Lakes were chemically analyzed for several forms of phosphorus and bioassayed under aerobic conditions to measure the release of algal-available phosphorus. The bioassay data for all samples, interpreted through a first-order model of available phosphorus release, showed an average of 21.8 percent of the total particulate phosphorus ultimately was available to *Selenastrum capricornutum*, and available phosphorus was released at an average rate of 0.154 day^{-1}. Amounts of available phosphorus varied considerably between tributaries with the Ohio tributaries (Maumee, Sandusky, and Cuyahoga Rivers) showing generally greater amounts than those in New York (Cattaraugus and Genesee Rivers). Non-apatite fractions of inorganic phosphorus (base-, and reductant-extractable) correlated well with levels of available phosphorus in the suspended sediment samples; however, the first-order release coefficients showed little dependency on the particulate phosphorus characteristics. The results indicate that prediction of phosphorus dynamics in the lower Great Lakes may be made with greater accuracy than current models allow by considering available phosphorus to be released from an ultimately-available fraction of the total particulate phosphorus during residence in the water column.

Dolan, D. M., A. K. Yui, and R. D. Geist. 1981. Evaluation of River Load Estimation Methods for Total Phosphorus. J. Great Lakes Res., Internat. Assoc. Great Lakes Res. 7(3): 207-214. ERL-D Reprint #295.

> Accurate estimates of pollutant loadings to the Great Lakes are required for trend detection, model development, and planning. On many major rivers, infrequent sampling of most pollutants makes these estimates difficult. However, most large rivers have complete daily flow records available from the U.S. Geological Survey. A number of different estimation methods have been developed to use these data in conjunction with available concentration data to calculate pollutant loadings. Several of these methods have been evaluated in this paper for a typical major tributary.
>
> Intensive measurements of pollutant loadings to Lake Michigan from the Grand River in 1976-1977 were conducted by USEPA, Region V. Daily concentrations of several chemical parameters, including total phosphorus, were determined. This information, together with daily river flow rates from USGS, provide an excellent data set for testing various load estimation methods. Ten different methods were tested using 680 randomly generated 25-sample subsets of the daily total phosphorus data set. The methods tested include several simple calculation schemes, as well as flow-concentration correlations and the stratified ratio estimator. The latter method is shown to be at least slightly better than the others for these data and for this type of sampling, including when sampling is concentrated during periods of high flow.

Eisenreich, S. J., B. B. Looney, and J. D. Thornton. 1981. Airborne Organic Contaminants in the Great Lakes Ecosystem. Environ. Sci. Technol. 15(1): 30-38.

> Atmospheric fluxes to the Great Lakes are a combination of dry and wet removal processes. These processes are outlined for selected contaminants. Dry deposition is 1.5-5.0 times the wet deposition for the trace organics, selected-chlorinated pesticides and polychlorinated biphenyls.

Evans, J. E., T. C. Johnson, E. C. Alexander, Jr., R. S. Lively, and S. J. Eisenreich. 1981. Sedimentation Rates and Depositional Processes in Lake Superior from ^{210}Pb Geochronology. J. Great Lakes Res. 7(3): 299-310.

> Sedimentation rates range from 0.01 to 0.32 cm/yr in 17 sediment box cores from Lake Superior, as determined by ^{210}Pb geochronology. Shoreline erosion and resuspension of nearshore sediments causes moderate to high (0.05-0.11 cm/yr) sedimentation rates in the western arm of Lake Superior. Sedimentation rates are very high (>0.15 cm/yr) in marginal bays adjoining Lake Superior; and moderate to very high (0.07-0.19 cm/yr) in open lake regions adjacent to marginal bays.

Resuspension of nearshore and shoal top sediments in southern and southeastern Lake Superior by storms is responsible for depositional anomalies of ^{210}Pb profiles corresponding to 1905, 1916-1918, and 1940 storms. Sedimentation rates are very low (0.01-0.03 cm/yr) in the central basins due to isolation from sediment sources. These data indicate that sedimentation rates and processes vary significantly in different regions of Lake Superior. The sedimentation rates provided by this study, in conjunction with previously-reported sedimentation rates, yield a better understanding of the Lake Superior depositional environment.

Fisher, J. B., and G. Matisoff. 1981. High Resolution Vertical Profiles of pH in Recent Sediments. Hydrobiologia 79: 277-284.

High resolution (0.1 cm sampling interval) profiles of pH were obtained from some recent estuarine (Long Island Sound, Chesapeake Bay) and freshwater (Lake Erie) sediments and from laboratory microcosms containing homogenized Lake Erie sediment (both with and without tubificid oligochaetes) by incrementally processing a micro-pH electrode downward through the sediment. These profiles revealed that hydrogen ion undergoes chemical reactions on a scale smaller than can be resolved using classic 1 cm sampling intervals, and that the vertical distribution of hydrogen ion is affected by bioturbation. In all sediments examined, a local pH minimum occurred immediately below the oxidized zone. In estuarine sediments, a second deeper pH minimum was observed. The presence of tubificids prevented profound pH changes from developing in microcosm sediments treated with a layer of activated sewage sludge and resulted in more modest alterations of pH profile in microcosm sediments lacking such a layer. The technique used in this study is by no means limited to pH. In principal, any chemical species that can be directly determined by electrodes (e.g. O_2, S^{-2}) may be studied. Microelectrode techniques could be especially useful in the study of chemical gradients around animal burrows and in time series studies of whole core diagenesis.

Gerhart, E. H., R. J. Liukkonen, R. M. Carlson, G. N. Stokes, M. Lukasewycz, and A. R. Oyler. 1981. Histological Effects and Bioaccumulation Potential of Coal Particulate-Bound Phenanthrene in the Fathead Minnow *Pimephales promelas*. Environ. Pollut. (Series A), 25: 165-180. ERL-D Reprint #253.

Fathead minnows *Pimephales promelas* were exposed to phenanthrene adsorbed to <125 μm coal particulates in a 14-day flow-through exposure to determine changes in histology and bioaccumulation. Based on light microscopic examination, coal particulates caused no obvious damage to external surfaces such as gills or skin and particulates were not observed to have accumulated in internal tissues. However, coal particles were readily ingested and this was followed by extensive mucous secretion by the gut mucosa. In addition, electron micrographs of the gut showed mucous globules in coal-exposed epithelium but no erosion of microvilli. Phenanthrene bioaccumulation was compared in fish exposed to dissolved aqueous phenenthrene and fish exposed to dissolved aqueous phenanthrene plus coal particulate-bound phenanthrene. Enhanced phenanthrene uptake was not measured in coal-exposed fish and bioconcentration factors were 1,000 - 4,000 during the 14-day exposure period. Elimination of coal from the gut and phenanthrene from the tissues was rapid; both were undetectable after a 24-hour depuration period.

Glass, N. R., G. E. Glass, and P. J. Rennie. 1981. Effects of Acid Precipitation in North America. Environ. Int. 4: 443-452. ERL-D Reprint #255.

Recent evidence indicates that acid rain is a growing environmental phenomenon of potentially far reaching consequences and increasing geographical extent in North America. Acid rain is but one aspect of the broader problem of atmospheric depostion which includes snow, fog, and dry deposition of material. First noticed and studied in the Scandinavian countries, acid precipitation has now been well documented in the United States, first in the Northeast and now more recently throughout much of the United States east of the Mississippi River. Numerous streams and lakes in regions with poorly buffered soils have become devoid of fish, have an impoverished aquatic flora and fauna, and are changing toward conditions of low aquatic productivity. Evidence also indicates that acid precipitation may cause damage to forest growth, crop production, and man-made materials such as buildings, metals, paints, and statuary.

Gotham, I. J., and G.-Y. Rhee. 1981. Comparative Kinetic Studies of Nitrate-Limited Growth and Nitrate Uptake in Phytoplankton in Continuous Culture. J. Phycol. 17: 309-314.

A comparative kinetic study of nitrate-limited growth and nitrate uptake was carried out in chemostat cultures of Ankistrodesmus falcatus (Corda) Ralfs., Asterionella formosa Hass., Fragilaria crotonensis Kit. In each species growth rate (μ) was related to total cell nitrogen or cell quota (q) by the empirical Droop growth function. Nitrate uptake was a function of both external N concentration and q. The apparent maximum uptake rate (V_m') at a given μ was inversely related to $q - q_o$, where q_o is the minimum quota. The apparent half-saturation constant for uptake (K_m') appears to show a slight inverse trend with μ, although statistical analysis shows that this trend is inconclusive. When q approaches q_o, V_m' is several orders of magnitude greater than μq, the calculated steady-state uptake rate. As q increases, however, the difference between these two variables decreases sharply until q appraoches q_m, the cell quota for nitrogen-rich cells. At this point the difference between μq and V_m' disappears. This behavior is explained by the feedback regulation of N uptake. The inverse relationship between V_m' and $q - q_o$ can be described by an empirical three-parameter equation.

Gotham, I. J., and G.-Y. Rhee. 1981. Comparative Kinetic Studies of Phosphate-Limited Growth and Phosphate Uptake in Phytoplankton in Continuous Culture. J. Phycol. 17: 257-265.

A comparative kinetic study of phosphate-limited growth and phosphate uptake was carried out in chemostat cultures of *Anabaena flos-aquae* Lyng. Breb., *Ankistrodesmus falcatus* (Corda) Ralfs, *Asterionella formosa* Hass., *Fragilaria crotonensis* Kitt., and *Microcystis* sp. Lemm. For each test organism the growth rate (μ) can be described as a function of total cell phosphorus (P), i.e. cell quota (q), or hot-water-extractable P (q_{sp}). Phosphate uptake rate in each species examined was a function of external P concentration (S) and intracellular P levels. The substrate parameter for uptake (K_m) remained constant at all growth rates, but the apparent maximum uptake rate (V_m') increased with decreasing μ, or q, in all test organisms. At low growth rates V_m' was greater than the calculated steady-state uptake rate (μq) by two to three orders of magnitude because V_m' is the uptake rate of $S > K_m$ and μq is the rate of $S < K_m$. The difference between V_m' and μq decreased and virtually disappeared as approached the physiological maximum growth rate (μ_m), where $q = q_m$ and $S > K_m$. An inverse relationship existed between V_m' and q_{sp} which could be decribed by a function that mathematically resembles noncompetitive inhibition in enzyme kinetics. The inverse relation between V_m' and $(q - q_o)$ was described by a three-parameter function. This empirical function provided a good description of this inverse relation over the range from V_m' at q approaching q_o up to and including calculated net, maximum uptake rates at $q = q_m$.

Hall, L. H., and L. B. Kier. 1981. The Relation of Molecular Connectivity to Molecular Volume and Biological Activity. Eur. J. Med. Chem. - Chimica Therapeutica 16(5): 399-407.

A fundamental relation of the connectivity delta values δ^v and δ to van der Waals volume is presented. Excellent correlations are also shown between experimental partial molal volume and connectivity indexes for a set of 48 ketones, alcohols and ethers and for a set of 18 quaternary ammonium salts. Three QSAR studies previously performed using volume as a correlate are shown to give excellent correlations using molecular connectivity. The biological data sets include the local anesthetis activity of N-[(N',N'-disubstituted amino)acetyl]arylamines, inhibition of *S. aureus* by penicillins and toxicity of the Madison 517 fungus to a set of oxygenated compounds. QSAR analysis of each data set is given in terms of molecular structure and comparison is made to other methods. The chief advantages of the connectivity method are summarized.

Hall, R. J., and G. E. Likens. 1981. Chemical Flux in an Acid-Stressed Stream. Nature 292(5821): 329-331.

The acidity of rain and snow falling on widely separated areas of the world has been increasing during the past 30 yr. Acid rainfall consists of a dilute solution of sulphuric and nitric acids due to the oxidation and hydrolysis of airborne sulphur and nitrogen and frequently has a pH of <4.0. Recent studies have shown that acid rain alters the chemistry and biology of streams and lakes in large regions of the world. Results from reconnaissance studies in the field and physiological studies in the laboratory show that diversity and numbers of aquatic organisms of all major trophic levels are affected by low pH (high acidity). The quantitative effects of such acidification on biogeochemistry and biological function in natural streams have received little attention. In contrast, much is known about aquatic ecosystems affected by acid mine drainage. However, waters receiving acid mine drainage show effects caused by metal contamination and deposition of iron oxide particulates, as well as acidification. In our study, we experimentally acidified a third-order section of a small mountain stream in the Hubbard Brook Experimental Forest, West Thornton, New Hampshire, USA. Our aim was to measure the effects of increased acidity on chemical and biological export in the stream. It was found that experimental stream acidification to pH 4 did alter the chemical and biological flux. The most significant inorganic component affected by the experiment was aluminum. A significant net flux of carbon and nitrogen occurred in the biologically bound forms but not in dissovled substances. Net flux of phosphorus was significant in biologically bound forms. The increased loss of nutrients in the particulate organic fraction was also important, particularly if scaled to the total stream ecosystem.

Heinrich, J., W. Lick, and J. Paul. 1981. Temperatures and Currents in a Stratified Lake: A Two-Dimensional Analysis. J. Great Lakes Res. 7(3): 264-275.

Two-dimensional, time-dependent numerical models are used to predict the temperatures and currents in a stratified lake. In this study, (1) essential features of the observed distributions of temperatures and currents in large, stratified lakes, especially Lake Erie, are reproduced, (2) the effects of various governing parameters such as heat flux to the water, wind stresses, and turbulence are examined, and (3) the effects of changes in various parameters appearing in the turbulent eddy coefficients are investigated. The emphasis is on the general characteristics of thermocline formation, maintenance, and decay and therefore the time scales of interest are weeks and months rather than hours or even days.

Holtschlag, D. J. 1981. Flow Model of Saginaw River Near Saginaw, Michigan. U.S. Department of the Interior, Geological Survey, Open-File Report 81-1061, 20 pp.

An unsteady-flow simulation model was applied to a 19.5-mile reach of Saginaw River. The model provides a method of determining instantaneous discharge for flows from -8,000 to 12,000 cubic feet per second. The currently used slope-rating method can be utilized to compute discharge only under steady and high-flow conditions. Unsteady flow frequently occurs in the Saginaw River as a result of a lake seiching.

Model computations are based on solution of the continuity and momentum flow equations, on hydraulic characteristics of Saginaw River, and on time-dependent boundary conditions. An implicit, finite-difference technique is used to solve the one-dimensional flow equations. Channel storage and conveyance characteristics were obtained from data collected during a 1979 field survey and through model calibration. Boundary conditions are specified by stage or discharge data at the model extremities. Optionally, wind velocity data are incorporated in the flow simulations.

The model can simulate instantaneous stage and discharge data and summarize or plot the data. Simulations of low-flows are sensitive to small errors in stage data and to gentle breezes. Simulation of high flows for present channel conditions requires additional data and further study.

Hudec, T., J. Thean, D. Kuehl, and R. C. Dougherty. 1981. Tris(dichloropropyl)phosphate, a Mutagenic Flame Retardant: Frequent Occurrence in Human Seminal Plasma. Science 211(27): 951-952. ERL-D Reprint #240.

Negative-chemical-ionization mass spectral screening of extracts of human seminal plasma has revealed a presence of a Cl_7 ion cluster at a mass-to-charge ratio (m/z) of 463 in a significant number of the samples examined (34 out of 123). Experiments with different gases used to generate the negative-chemical-ionization plasma indicated that the ion at m/z 463 was a chloride adduct of a Cl_6 molecule with a mass of 428 daltons. Negative-chemical-ionization mass measurement with ions from the iodoform mass spectrum used as reference peaks gave a mass of 427.882 daltons $C_9H_{15}O_4PCl_6$ has a molecular weight of 427.883. Extraction of polyurethane foam with toluene produced an extract that consistently gave a negative-chemical-ionization spectrum containing an intense Cl_7 ion at m/z 463. The component ionization spectrum containing an intense Cl_7 ion at m/z 463. The component producing this ions was isolated, and its proton nuclear magnetic resonance spectrum confirmed that it was tris(1,3-dichloro-2-propyl)phosphate, a mutagenic flame retardant. The negative-chemical-ionization screening evidence suggests that this flame retardant or its isomer tris(2,3-dichloro-1-propyl)phosphate, or both, are absorbed into the body from formulations in which they are used as flame retardants. Remedial action seems indicated to reduce human exposure to these compounds.

Imlay, M. J., J. W. Arthur, B. J. Halligan, and J. H. Steinmetz. 1981. Life Cycle of the Freshwater Snail *Campeloma decisum* (Viviparidae) in the Laboratory. The Nautilus 95(2): 84-88.

Campeloma decisum reared in Minnesota Lake Superior water grew consistently well when clam meat or commercial fish food was provided and a substrate of sand or mud was present. Food alone, or the substrate alone, was generally ineffective in promoting growth. Thick substrates were more effective than thin substrates. Substrate depth was directly correlated with growth, although some growth occurred when no soft substrate was present. *Campeloma decisum* tested in Missouri hard well water grew equally well with or without a substrate. A population of newborn snails from the St. Croix River, Wisconsin was reared through three generations in 42 months on a diet of clam meat and trout chow with St. Croix River mud substrate. Survival of the original snails to 41 months was 80%.

Jaworski, N. A. 1981. Sources of Nutrients and the Scale of Eutrophication Problems in Estuaries. IN: Estuaries and Nutrients (B. J. Neilson and L. E. Cronin, eds.), pp. 83-100, The Humana Press. ERL-D Reprint #258.

A comprehensive analysis of external sources of nutrients is presented including an impact, comparison of external loadings, and the resulting scale of eutrophication. The major emphasis of the analysis is on nitrogen and phosphorus.

The relative contribution of various external sources for five major ecosystems is delineated. Discussion of seasonal and long-term trends of external sources is presented. The impact of external sources on the eutrophication process is evaluated. A scale of eutrophication for estuarine ecosystems is suggested for comparing the impact of nutrient enrichment.

Comparisons of external nutrient loadings and the scale of eutrophication for 13 estuarine and freshwater ecosystems are made. A detailed comparison of the five estuaries of the Chesapeake Bay is presented from which relationships between external nutrient loadings ($g/m^2/yr$) and eutrophic conditions are suggested.

Analysis of the relationship between external nutrient loadings, nitrogen/phosphorus ratio, and eutrophic state suggests that, for the East Coast estuarine ecosystems, if the phosphorus loading is 1.0 $g/m^2/yr$ or less, excessive eutrophic conditions can be prevented. The favorable response of the Potomac estuary to phosphorus control demonstrates that excessive eutrophic conditions may be alleviated with advanced wastewater treatment, depending on many factors including nutrient loadings.

Jaworski, N. A., and O. Villa, Jr. 1981. A Suggested Approach for Developing Estuarine Water Quality Criteria for Management of Eutrophication. IN: Estuaries and Nutrients (B. J. Neilson and L. E. Cronin, eds.), pp. 499-516, The Humana Press. ERL-D Reprint #259.

> A conceptual approach for developing water quality criteria for eutrophication management is suggested. The three basic components of the framework include source ambient relationships, effects, and impact analyses. The approach focuses on a conceptual method for developing decision-making criteria as opposed to the classical water quality criteria of a single value of limitation. The approach to developing water quality criteria for eutrophication management provides an analysis framework of response relationships which can be readily incorporated into water quality standard-setting processes that include environmental considerations and technological and economic factors.

Jordan, T. F., K. R. Stortz, and M. Sydor. 1981. Resonant Oscillation in Duluth-Superior Harbor. Limnol. Oceanogr. 26(1): 186-190.

> Treatment of Duluth-Superior Harbor inlets as coupled oscillators yields Helmholtz resonance periods of 2.1-2.3 h. Analysis of water level oscillations in the harbor and currents in an inlet channel shows a 2.1-h mode, which seems to be excited by lake oscillations of nearly the same period.

Kier, L. B. 1981. Quantitation of Solvent Polarity Based on Molecular Structure. J. Pharm. Sci. 70(8): 930-933.

> A numerical index is proposed that ranks solvents according to their polarity. It is based entirely on structure, encoding the relative content of exterjacent electrons in the molecule. The index is the first-order valence molecular connectivity index, ${}^1\chi^\upsilon$. The index is modified for the number of isolated functional groups in the molecule. A comparison with solvent polarity indexes based on several experimental methods reveals a good relationship. The polarity index proposed can be quickly calculated, it does not depend on the availability of the actual molecule, and it permits prediction of solvent polarity or the polarity of mixtures.

Kier, L. B., and L. H. Hall. 1981. Derivation and Significance of Valence Molecular Connectivity. J. Pharm. Sci. 70(6): 583-589.

> The physical basis for valence molecular connectivity was studied. The δ^υ and δ values are cardinal numbers describing the electronic structure of atoms in their valence states. The value $\delta^\upsilon + \delta$ describes the volume of a bonding atom while the value $\delta^\upsilon - \delta$ describes the electronegativity.

By using the principle of electronegativity equalization, bond electronegativity is defined as $(\delta_i^{\upsilon}\ \delta_j^{\upsilon})^{-1/2}$, and the valence molecular connectivity index $({}^{1}\chi^{\upsilon})$ is derived as a sum of these bond descriptions. The valence chi index is interpreted in terms of the information encoded, describing both the volume and electronic characteristics of bonds in molecules. Examples of close relationships with molecular volume and electronic properties are shown. A new way of estimating valence state electronegativity is proposed from a count of exterjacent electrons divided by the quantum number squared for at least the first three quantum levels.

Korfmacher, W. A., G. Mamantov, E. L. Wehry, D. F. S. Natusch, and T. Mauney. 1981. Nonphotochemical Decomposition of Fluorene Vapor-Adsorbed on Coal Fly Ash. Environ. Sci. Technol. 15(11): 1370-1375.

Fluorene is representative of a group of polycyclic aromatic hydrocarbons that have been shown to exhibit oxidation in the absence of light when adsorbed on fly ash. The present study examines this process for fluorene in detail. Fluorene has been adsorbed on several different fly ashes and other adsorbents including activated carbon, molecular sieves, alumina, silica gel, and Ambersorb XE-340. In addition, the rate of decomposition of fluorene vapor-adsorbed on one of the fly ashes has been studied, and the effect of the amount of fluorene adsorbed on the fly ash upon its nonphotochemical oxidation has been determined. The significance of the results in terms both of atmospheric dispersal of polycyclic aromatic hydrocarbons and of sampling these compounds for chemical analysis is discussed.

Krezoski, J. R., and J. A. Robbins. 1981. Radiotracer Studies of Interactions Between Sediments and Freshwater Macrobenthos. Verh. Internat. Verein. Limnol. 21: 382.

Gamma-emitting radioisotopes were used to study the effect of five species of benthic macrofauna, common to the North American Great Lakes, on the movement of solutes and particles in sediments. In three replicate cells with the annelid *Stylodrilus heringianus* (6.7×10^4 m^{-2}), which feeds at 4-6 cm and defecates at the sediment surface, the Cs-137 labeled layer was buried at a rate of 0.12 ± 0.005 cm day^{-1} ($11.6 \pm 0.2°C$) while the downward movement of Na-22, characterized as simple diffusion (no advection), implied a diffusion coefficient D_b, of $1.33 \pm 0.07 \times 10^{-5}$ $cm^2\ sec^{-1}$. In two replicate cells with the amphipod *Pontoporeia hoyi* (4.7×10^3 m^{-2}) D_b was $1.43 \pm 0.25 \times 10^{-5}$ $cm^2\ sec^{-1}$ ($10.4 \pm 0.2°C$). The downward smearing of Cs-137 labeled particles by amphipods is well characterized as a non-advective eddy diffusion process with an eddy diffusion coefficient, K_b, of $1.24 \pm 0.17 \times 10^{-7}$ $cm^2\ sec^{-1}$. In control cells with no animals $K_b = 0.0$ while $D_b = 0.95 \pm 0.02 \times 10^{-5}$ $cm^2\ sec^{-1}$. In a special control cell with worm tubes but no live worms, there was no enhancement of the rate of solute transport. Thus, the presence of either species markedly enhances the transport of solutes into sediments (~50%) and in the case of oligochaetes the effect is primarily due to their dynamic interactions with the sediments rather than to alterations in the sediment matrix. In other cells with *Chironomus tentans* (4.0 x 10^3 m^{-2}), *Pisidium* sp. (4.0 x 10^3 m^{-2}) and *Sphaerium* sp. (2.7 x 10^3 m^{-2}) no significant movement of labeled particles occurred.

Kuehl, D. W. 1981. Unusual Polyhalogenated Chemical Residues Identified in Fish Tissue from the Environment. Chemosphere 10(3): 231-242. ERL-D Reprint #242.

A review of polyhalogenated xenobiotic chemicals identified in fish obtained from environmental sampling is presented. The review does not include chemicals routinely reported in pesticide and polychlorinated biphenyl monitoring, nor chemicals studied in fish bioassay experiments.

Kuehl, D. W., K. L. Johnson, B. C. Butterworth, E. N. Leonard, and G. D. Veith. 1981. Quantification of Octachlorostyrene and Related Compounds in Great Lakes Fish by Gas Chromatography - Mass Spectrometry. J. Great Lakes Res. 7(3): 330-335. ERL-D Reprint #285.

Residues of octachlorostyrene (OCS) and related polychlorinated compounds including isomers of heptachloro-, hexachloro-, and pentachlorostyrene; hexachlorobenzene, pentachlorobenzene, isomers of tetrachloro- and trichlorobenzene; and hexachlorobutadiene have been quantitated by multiple-ion-detection gas chromatography-mass spectrometry in Great Lakes fish collected between 1974 and 1980. The results show that the two upper lakes, Superior and Michigan, do not appear to have residues of OCS greater than 5 ng/g, while residues in the lower lakes, Huron, Ontario, and Erie, are as high as 400 ng/g. A selected tributary to Lake Erie has been shown to contain very high levels of all of the chemicals studied which suggests one possible source of chlorostyrenes in the Great Lakes.

Lee, D.-Y., W. Lick, and S. W. Kang. 1981. The Entrainment and Deposition of Fine-Grained Sediments in Lake Erie. J. Great Lakes Res. 7(3): 224-233.

A series of entrainment and deposition experiments was performed with the general purpose of increasing our understanding of the parameters on which entrainment and deposition depend and the specific purpose of obtaining entrainment rates for a variety of sediments from the western basin of Lake Erie. The experiments were performed in an annular flume. A rotating top produced a turbulent flow which in turn exerted a turbulent shear stress on the sediments deposited on the bottom of the flume. Four different sediments from the western basin of Lake Erie were analyzed. Large variations in entrainment and deposition rates occurred and are shown to be dependent on the shear stress water content (time after deposition), the type of sediment (grain size and mineralogy), and the manner of deposition. In the interpretation of the experiments, it is necessary to consider the frequency distribution of sediment properties as well as the average properties.

Lin, C. K., and C. L. Schelske. 1981. Seasonal Variation of Potential Nutrient Limitation to Chlorophyll Production in Southern Lake Huron. Can. J. Fish. Aquat. Sci. 38: 1-9.

Potential nutrient limitation to chlorophyll production in surface waters of southern Lake Huron was assayed monthly from April to December 1975. Natural phytoplankton assemblage responses to nutrient enrichment were determined from chlorophyll production in laboratory incubations under seasonally varied light and temperature conditions. Experimental treatments included a complete treatment containing P, N, Si, EDTA, vitamins, and trace metals; treatments with deletions from the complete treatment; complete treatments and different P concentrations; and treatments with single nutrient additions. Effects were most pronounced during summer and fall when P, EDTA, FeEDTA, vitamins, and Si were added simultaneously. The intensity of the effect resulting from additions of phosphorus and other nutrients varied seasonally. Individual additions of EDTA, N, and Si had little effect as did deletion of N from the complete treatment. Addition of P alone resulted in limited growth. Deletion of phosphorus from the complete enrichment, however, reduced growth drastically during most experimental period. In the complete treatment the minimum levels of P that caused significant chlorophyll production ranged from 1 to 3 $\mu g\ l^{-1}$. Chelate (EDTA), chelated iron, and vitamins were important secondary limiting nutrients during the summer months. There was a small effect due to silica in July, September, and October, and no indication of deficiency in trace metals. Trace metals, when deleted, frequently produced greater chlorophyll than the complete treatment, but growth was sharply reduced by deletion of trace metals and EDTA combined. The results clearly demonstrate that large increases in chlorophyll production in southern Lake Huron require simultaneous additions of the primary limiting nutrient (P) and secondary limiting nutrients (EDTA, FeEDTA, and vitamins) which vary seasonally.

Lind, A. E., and G. E. Glass. 1981. Asbestos Contamination of Lake Superior: Ten Years of Litigation - U.S.A. vs. Reserve Mining Company. IN: Contaminants and Sediments, Volume 1, Fate and Transport, Case Studies, Modeling, Toxicity, (R. A. Baker, ed.), pp. 219-270, Ann Arbor Science Publishers, Ann Arbor, Michigan.

Studies focusing on the impacts of the largest industrial discharge in the U.S. (Reserve Mining Company, Silver Bay, Minnesota) to the largest freshwater lake, Lake Superior, have been subjected to intensive scientific and legal scrutiny from 1969-1978. The period of greatest activity was during the 139 day Federal District Court trial in which over 100 witnesses presented testimony and 1,621 exhibits, and generated 18,000 pages of transcript (1). The issues ranged from eutrophication of the lake (2,3) to asbestos caused cancer (4). The Court has ordered the Company to pay fines of $1,200,000, use on-land disposal of tailings by 1980, and to provide filtered water for municipalities using Lake Superior water. A discussion and summary of the findings of fact, technical studies, and current disposition of the case will be presented. (1. Lord, M. W., U.S. District Court, District of Minnesota. Fifth Division, 5-72 Civil 19, April 20, 1974; 2. Shapiro, J, and Glass, G. E., Verh. Internat. Verein. Limnol. 19, 395 (1975); 3. Glass, G. E., and Poldoski, J. E., Ibid, 405 (1975); 4. Cook, P. M., Glass, G. E., and Tucker, J. H., Science 185, 853 (1974).)

McCormick, J. H., M. J. Ross, and D. B. Siniff. 1981. To Go to Florida for the Winter or Not to Go to Florida, That is the Question: Where Do Yellow Perch (Perca flavescens) Go in Winter When Given the Option Between Normal Ice Covered Waters or a Heated Discharge. IN: Proceedings of the Seventh Annual Aquatic Toxicity Workshop, (N. Bermingham et al., eds.), pp. 35-45, November 5-7, 1980, Montreal, Quebec. ERL-D Reprint #245.

It is necessary in order to protect indigenous fishes, to require cooling of heated discharges during the winter; and if necessary, to what degree should such cooling be required and for what period of time? These are the questions we attempted to answer in a series of laboratory and field tests.

In the first laboratory test with yellow perch (Perca flavescens), we learned that a winter chill period was required for successful spring spawning. Spawning was most successful among yellow perch held over winter at 4°C for 185 days and was progressively poorer at 6, 8, and 10°C and as the chill period at 4°C was shortened or extended beyond 185 days. Another laboratory study with yellow perch to determine their preferred temperature on a seasonal basis showed that adult yellow perch in winter seek water at tempertures from 12 to 14°C when acclimated to 5°C and that their final winter preference is 24°C.

Under natural winter conditions, 4°C is the warmest water available but given the choice between normal winter temperatures and a thermal discharge where will yellow perch be found? The information gained from the laboratory tests just described suggests that they may choose the thermal discharge. This was such an important concept that field testing was deemed justified.

To determine whether yellow perch preferred thermal discharge to normal temperature water in the field, a series of radio telemetry studies were undertaken. Techniques for periodic determination of location of radio-tagged fish and determination of water temperature at these locations were used. Thermal exposures of individual fish were necessary to estimate their cummulative thermal experience. Thermal exposures were determined by matching fish locations to thermo-isopleths on maps of the thermal plume from the discharge and by thermo indicative signals from externally attached radio tags.

Radio tracking revealed that yellow perch do not respond to temperature independence of other field present factors as they do in a laboratory gradient tank where single factor responses are carefully sought. In the field, yellow perch respond to an array of stimuli that result in net directional or habitat selection response, where temperature exerts its influence along with all of the other factors and as they shift with the season or with time of day.

McCormick, J. H., and J. A. Wegner. 1981. Responses of Largemouth Bass from Different Latitudes to Elevated Water Temperatures. Trans. Am. Fish. Soc. 110: 417-429. ERL-D Reprint #252.

The effects of elevated temperatures on largemouth bass Micropterus s. salmoides, from Minnesota and Wisconsin (our northern stock) and from Tennessee (our southern stock), were compared at four first-year life stages. Our purpose was to determine if data gathered from one part of a species' range could be used to set thermal standards for that same species elsewhere within its normal range. Eggs and embryos, when first exposed early in development to an array of elevated temperatures, lost 50% of their maximum hatching success (TL50) at 29.5 C for the northern stock and at 29.1 C for the southern stock. When embryos from the same pooled egg lots were exposed late in development, their TL50 temperatures were 32.3 C and 30.9 C, respectively. Median lethal 24-hour temperatures (TL50) for 0-3-day-old hatched larvae acclimated to 20, 24, 27, and 30 C averaged 32.1 C for the northern stock and 32.6 C for the southern stock. Median survival times for juveniles depended on acclimation temperature, exposure temperature, and the difference between these. Expected 24-hour TL50 temperatures, derived from median survival times, are 31.0 C for the northern stock and 30.6 C for the southern, based on 22 C acclimation. When fish were reared at temperatures from 28 to 35 C for 6 weeks growth rates were not significantly different among temperatures or between stocks. At 35 and 36 C for the northern and at 36 C for the southern stock, mortality rates were significantly elevated and net biomass gains were significantly depressed, although neither variable differed between stocks ($P > 0.05$). The differences between stock tolerances exceeded 1 C in only one of the elevated temperature challenges performed (1.4 C for the TL50 of late-exposed embryos) and neither stock was consistently more or less thermally tolerant. We conclude that, in terms of responses to elevated thermal challenges, M. s. salmoides is a thermally consistent subspecies over the latitudinal range represented by our samples. We further conclude that thermal standards for these fish may be based on data obtained from samples taken from any usual population within this range, provided a 2 C safety factor is used where TL50 data are involved.

Mizera, J. J., C. L. Cooper, and C. E. Herdendorf. 1981. Limnetic Larval Fish in the Nearshore Zone of the Western Basin of Lake Erie. J. Great Lakes Res. 7(1): 62-64.

> Gizzard shad/alewife, *Dorosoma cepedianum*/*Alosa pseudoharengus*, emerald shiners, *Notropis atherinoides*, white bass/white perch, *Morone chrysops*/*Morone americana*, and yellow perch, *Perca flavescens*, constituted over 97% of the larval fish collected in Ohio and Mighigan waters of the western basin of Lake Erie during 1977. Significantly greater numbers of gizzard shad/alewife and spottail shiner, *Notropis hudsonius*, larvae were captured immediately adjacent to the shore than at a depth of 5 m offshore while greater numbers of smelt, *Osmerus mordax*, larvae were captured at points further offshore at a depth of 5 m than at points immediately adjacent to the shore. Significantly greater numbers of walleye, *Stizostedion vitreum*, larvae were collected along the Ohio shoreline portion of the study area than in Maumee Bay or along the Michigan shoreline. Significantly greater numbers of freshwater drum, *Aplodinotus grunniens*, larvae were collected in Maumee Bay.

Mount, D. I. 1981. Margins of Safety for Aquatic Communities. IN: Aquatic Toxicology and Hazard Assessment: Fourth Conference, ASTM STP 737, (D. R. Branson and K. L. Dickson, eds.), pp. 5-9, American Society for Testing and Materials. ERL-D Reprint #261.

> The margin of safety is the difference between the expected effect concentrations and the expected ambient concentrations. Two sources of variability, error in the test data and unknown information, necessitate a margin of safety. Inclusion of site-specific considerations can substantially reduce needed margins. The choice of the appropriate confidence level should be based on the importance of the decision and not on habit.

Mullin, M. D., and J. C. Filkins. 1981. Analysis of Polychlorinated Biphenyls by Glass Capillary and Packed-Column Chromatography. IN: Advances in the Identification and Analysis of Organic Pollutants in Water, Vol. 1 (L. H. Keith, ed.), Chapter 11, pp. 187-196, Ann Arbor Science, Ann Arbor, Michigan.

> The vast majority of North American laboratories analyzing environmental samples for PCB utilize some form of gas chromatography (GC) with conventional packed-column chromatography and an electron capture detector (ECD). A growing number of these facilities are also equipped with mass spectrometers for more detailed, but less sensitive, analyses.
>
> The alternative to these techniques is the use of high-resolution glass capillary GC. The use of glass capillary GC enables the identification of individual components in complex environmental samples which will be invaluable to toxicologists in aiding them to evaluate compounds for

potential toxicological importance that are known to be present in environmental samples. In addition, glass capillary GC will enable analysts to better quantify the compounds in their samples by minimizing interferences and more accurately quantifying the resulting chromatograms.

Mullin, M., G. Sawka, L. Safe, S. McCrindle, and S. Safe. 1981. Synthesis of the Octa- and Nonachlorobiphenyl Isomers and Congeners and their Quantitation in Commercial Polychlorinated Biphenyls and Identification in Human Breast Milk. J. Anal. Toxicol. 5(May/June): 138-142.

The synthesis of all possible isomeric nona- and octachlorobiphenyls has been accomplished by the Cadogan coupling of commercially available or synthetic chlorinated anilines in the presence of excess chlorinated benzenes and isoamyl nitrite. 2,3,4,6-Tetrachloroaniline was prepared by the chlorination of 2,4,5-trichloroaniline. The synthetic polychlorinated biphenyls (PCBs) were characterized by their proton magnetic resonance and mass spectra and their purities determined by gas chromatographic analyses. The PCB standards were used to unambiguously identify the deca-, nona-, and octachlorobiphenyls present in human breast milk and in the commercial PCB preparations Aroclors 1268, 1262, 1260, 1254, 1248, 1242, 1016, 1232 and 1221 utilizing high resolution glass capillary gas chromatography.

Murphy, T. J., A. Schinsky, G. Paolucci, and C. P. Rzeszutko. 1981. Inputs of Polychlorinated Biphenyls from the Atmosphere to Lakes Huron and Michigan. IN: Atmospheric Pollutants in Natural Waters (S. J. Eisenreich, ed.), Chapter 22, pp. 445-458, Ann Arbor Science, Ann Arbor, Michigan.

The present major source of PCB in Lake Michigan is the atmosphere. Results obtained with the event collectors indicate that the concentration of PCB in precipitation is variable. This, along with the observation that most of the particulates in the rain in Chicago occur in the early part of the rain, suggests that the PCB are principally associated with the particulates. Because of this association with particulates, and the high concentration of particulates in the early part of a rain event, the amount of PCB scavenged by precipitation is more a function of the number of events than of the amount of precipitation.

Nordlie, K., and J. W. Arthur. 1981. Effects of Elevated Water Temperature on Insect Emergence in Outdoor Experimental Channels. Environ. Pollut. (Series A) 25: 53-65. ERL-D Reprint #244.

Emergence of adult aquatic insects was evaluated weekly with plexiglass traps positioned in two outdoor experimental channels from April through August 1977. One channel was seasonal Mississippi River water temperature and the other maintained at 10°C above. Maximum water temperatures reached 31.0°C in the ambient and 40.8°C in the heated channels. Chironomids comprised 84% of the insects collected in both channels. Percentage composition differed between the ambient and heated channels for the chironomid taxa while the mayfly, damselfly and caddisfly taxa were more similiar. The temperature in the heated channel (10°C above ambient) advanced the emergence of two Chironomidae, one Orthocladiinae, one Ceratopogonidae, and one Zygopteran species by one to four weeks. Few insects emerged from the heated channel during the period of maximum temperature. Insect emergence was spatially distributed throughout each channel even though dissolved oxygen concentrations were near zero at sunrise and supersaturated at midafternoon hours at downstream stations.

Oman, G. J., and M. Sydor. 1981. Plume Development Using Lagrangian Marker Method. Journal of the Waterway, Port Coastal and Ocean Division, ASCE, 107(WW3): 131-148.

Currents as a function of wind were calculated by a depth integrated model of Lake Superior. Using the calculated currents, the development of large turbidity plume was numerically simulated. Good agreement between the simulated plume, remote sensing, and ground truth data provided verification of calculated current patterns and much insight into the ultimate fate of pollutants in western Lake Superior as a function of wind. The long range transport of a conservative pollutant from the Duluth-Superior harbor was simulated for westerly winds and for variable winds. For westerly winds, the model predicted that the contaminant would be transported along the Wisconsin shore away from the harbor area. For variable winds, the pollutant remained trapped in the southwest corner of the lake.

Pagenkopf, G. K., and C. Whitworth. 1981. Precipitation of Metal-Humate Complexes. J. Inorg. Nucl. Chem. 43: 1219-1222.

Concentrations of magnesium found in sea water are capable of precipitating cadmium humate from water solution. Speciation calculations and kinetic considerations indicate that dissociation of the cadmium complexes occurs during the precipitation process. For a sequence of divalent metal cations, lead is the most effective precipitator of humic acid, whereas magnesium is least effective. The order is lead > copper > cadmium > barium > zinc > nickel > calcium > strontium > magnesium.

Parkinson, A., L. W. Robertson, L. Safe and S. Safe. 1981. Polychlorinated Biphenyls as Inducers of Hepatic Microsomal Enzymes: Effects of Di-Ortho Substitution. Chem.-Biol. Interact. 38: 1-12.

> All of the 13 possible polychlorinated biphenyl (PCB) isomers and congeners substituted at both para positions, at least two meta positions (but not necessarily on the same ring) and at two ortho positions have been synthesized and tested as rat hepatic microsomal enzyme inducers. The effects of these compounds were evaluated by measuring microsomal benzo[a]pyrene (B[a]P) hydroxylase, 4-chlorobiphenyl (4-CBP) hydroxylase, 4-dimethylaminoantipyrine (DMAP) N-demethylase and NADPH-cytochrome c reductase activities, the cytochrome b_5 content and the relative peak intensities and spectral shifts of the carbon monoxide (CO)- and ethylisocyanide(EIC)-difference spectra of ferrocytochrome P-450. The results were compared to the effects of administering phenobarbitone (PB), 3-methylcholanthrene (MC) and PB plus MC (coadministered). At dose levels of 150 μmol · kg^{-1}, all of the PCB congeners, except 2,3',4,4',5', 6-hexachlorobiphenyl, significantly enhanced hepatic microsomal cytochrome P-450 content, B[a]P hydroxylase and/or DMAP N-demethylase activities compared to the control (corn oil-treated) animals. Only 5 of these compounds, namely 2,3,4,4',5,6-hexa-, 2,2',3,3',4,4'-hexa-, 2,2',3',4,4',5-hexa-, 2,3,3',4,4',6-hexa- and 2,2',3,3',4,4',5-heptachlorobiphenyl, enhanced microsomal B[a]P hydroxylase, 4-CBP hydroxylase, NADPH-cytochrome c reductase and DMAP N-demethylase activities in a manner consistent with a mixed pattern of induction. The results suggest that PCB isomers and congeners substituted at both para positions, at least two meta positions, at two ortho positions and containing a 2,3,4-trichloro substitution pattern on one ring are mixed-type inducers; in addition the effects of 2,3,4,4',5,6-hexachlorobiphenyl were also consistent with a mixed pattern of induction.

Phipps, G. L., G. W. Holcombe, and J. T. Fiandt. 1981. Acute Toxicity of Phenol and Substituted Phenols to the Fathead Minnow. Bull. Environ. Contam. Toxicol. 26: 585-593. ERL-D Reprint #247.

> The 96-h and 192-h LC50s were determined for phenol and 11 substituted phenols. The freshwater flow-through tests with measured concentrations and nearly identical test conditions used the fathead minnow Pimephales promelas as the test organism. The fish were checked for uniformity in toxicity response using 48-h static reference tests with 2,4-dichlorophenol as the toxicant. The results of these 12 tests produced a mean 48-h LC50 of 8.6 mg/l ± 1.1 mg/l.
>
> The mean of duplicate 96-h LC50s (mg/l) in ascending order of toxicity were: pentachlorophenol, 0.22; 4,6-dinitro-o-cresol, 2.0; 2,4,6-tribromophenol, 6.6; 2,4-dichlorophenol, 8.2; 2-chlorophenol, 12; 2,4-dinitrophenol, 17; 2,4-dimethylphenol, 17; 2,6-dimethylphenol, >27; phenol, 29; 4-nitrophenol, 61; and 3-methoxyphenol, 76.

Pratt, J. M., and R. J. Hall. 1981. Acute Effects of Stream Acidification on the Diversity of Macroinvertebrate Drift. IN: Effects of Acidic Precipitation on Benthos, (R. Singer, ed.), pp. 77-96, Proc. Symp. Acidic Precipitation on Benthos, 1980, North American Benthological Society, Hamilton, New York.

A third-order reach of Norris Brook, a small stream in the Hubbard Brook Experimental Forest, was experimentally acidified for five months to determine what effect acid precipitation may have on the ecology of a poorly buffered lotic ecosystem. The initial six days of stream acidification simulated a low pH regime that can occur in a small mountain stream receiving meltwater from a rapidly thawing snowpack contaminated with acidic deposition.

The first two to three days of acid addition constituted a period of acute H-ion stress (pH 4) that elicited a tenfold increase in the daily drift rate of benthic macroinvertebrates. This increased drift leaving the acidified reach was also more diverse overall in terms of major taxa (orders), trophic functional groups, and behavioral groups but less diverse at the generic level than the drift entering. In addition, the macrofauna abandoning the acidified area compared to that entering was particularly more diverse generically in mayflies and probably midges, collector-gatherers, and clingers and swimmers.

Ecological implications of the acute changes in drift rate and diversity extrapolated throughout the low-order (1-3) tributaries of a weakly buffering stream are discussed. Recommendations for monitoring the effects of acid precipitation on the ecology of acid-sensitive lotic ecosystems are offered.

Rhee, G.-Y., and I. J. Gotham. 1981. The Effect of Environmental Factors on Phytoplankton Growth: Light and the Interactions of Light with Nitrate Limitation. Limnol. Oceanogr. 26(4): 649-659.

The effects of simultaneous limitations of light and nutrient on growth were investigated with turbidostat and chemostat cultures of *Scenedesmus* sp. and *Fragilaria crotonensis*. The combined effects were greater than the sum of individual effects and were not multiplicative. Under nitrate-limited conditions the cell quota of the limiting nutrient for a constant growth rate and the subsistance quota (q_o) increased as irradiance decreased. Within a certain limit of growth rates, light and q_N can compensate for each other in maintaining growth rate. Under nutrient-sufficient conditions, cell quotas of C, N, and P, and cellular chlorophyll *a* concentration increased as light decreased below saturation. The cell quotas are the maximum level (q_m) that can be achieved at a given irradiance. Cell quotas of nonlimiting nutrients in nutrient-limited cultures are the same as these q_m values. The increasing levels of q_m and q_o with decreasing irradiance indicate that nutrient requirements increase as irradiance decreases.

Rhee, G.-Y., and I. J. Gotham. 1981. The Effect of Environmental Factors on Phytoplankton Growth: Temperature and the Interactions of Temperature with Nutrient Limitation. Limnol. Oceanogr. 26(4): 635-648.

> The combined stress of nutrient limitation and suboptimal temperature on growth was studied with turbidostat and chemostat cultures of *Scenedesmus* sp. and *Asterionella formosa*. The combined effects were greater than the sum of individual effects and were not multiplicative. In N- and P-limited *Scenedesmus* sp. and *A. formosa* the cell quotas (q) of both limiting and nonlimiting nutrients increased with decreasing temperature. At a given temperature cell quotas of limiting nutrients also increased with the growth rate (μ) and followed a saturation function. Higher values of the minimum cell quota (q_o) at lower temperatures show that cells require more nutrient with decreasing temperature. The change of q_o with temperature varies with the type of limiting nutrient. This change for N and P in *Scenedesmus* sp. suggests that their optimum ratio, the ratio at which one limitation changes over to the other, is higher at suboptimal temperatures. Cell quotas of nutrient-sufficient cultures (q_m) for C, N, and P and cellular chlorophyll *a* concentration increased with decreasing temperature. The quota of each nonlimiting nutrient in nutrient-limited cultures had the same values as q_m. The rate of protein synthesis per unit RNA decreased with temperature. The highest apparent maximum N uptake was observed at 15°C for N-limited *Scenedesmus* sp. growing at $0.5 \cdot d^{-1}$. The optimal growth temperature range, however, was 20°-25°C. The highest apparent maximum P uptake in *A. formosa* was found at 19°-20°C, when $\mu = 0.4 \cdot d^{-1}$. These temperatures were also optimal for growth.

Rhee, G.-Y., I. J. Gotham, and S. W. Chisholm. 1981. Use of Cyclostat Cultures to Study Phytoplankton Ecology. IN: Continuous Cultures of Cells, Volume 2, Chapter 7, pp. 159-186.

> Experiments using steady-state chemostat cultures under continuous light have significantly advanced our knowledge of physiological changes of phytoplankton under nutrient limitation. In this nonperiodic steady state, growth rate is independent of time and is determined only by dilution rate. Under these conditions, or if division cycles are disregarded, mathematical treatment of growth is simple. However, when a chemostat culture is illuminated for a part of a 24 hr period, growth is also a function of time during that photocycle. When growth of such a culture follows an identical pattern during each 24 hr cycle, it is termed a periodic cyclostat culture. Studies of these cultures provide information on algal division cycles and thus deepter insights into the ecology of these organisms.
>
> The ecological relevance of steady-state chemostat and cyclostat systems must be viewed within the context for which these systems are designed: nutrient-limited and time-independent growth. In cyclostats, growth is independent of time when averaged or integrated over the photocycle.

However, growth rate in natural systems is neither time independent nor steady state. Thus the time-independent states of chemostat or cyclostat systems are utterly unnatural. A chemostat or a cyclostat culture is useful in phytoplankton ecology only to elucidate general physiological, biochemical, and genetic principles as related to ecology, rather than to reproduce the conditions existing in the natural environment.

Since the use of continuous culture to study phytoplankton ecology has been reviewed recently, this article will concentrate on comparing the basic concepts of both chemostat and cyclostat systems.

Rodgers, P. W., and D. K. Salisbury. 1981. Modeling of Water Quality in Lake Michigan and the Effect of the Anomalous Ice Cover of 1976-1977. Great Lakes Environmental Planning Study (GLEPS), Great Lakes Basin Commission, Ann Arbor, Michigan, Contribution No. 44.

An intensive survey of water quality parameters was conducted on Lake Michigan during 1976 and 1977. A nutrient-phytoplankton model (MICH1) was developed and calibrated to data from 1976. MICH1 was then applied to data from 1977 in an attempt to simulate an observed phosphorus depletion of up to 3 μg-P/1. In order to account for this rapid phosphorus loss an implicit representation of the extreme ice cover which separated these survey years was necessary. This procedure included increasing the apparent settling rate eight fold during ice cover. A time variable total phosphorus model (TPM) was used in a hindcasting application which produced a reasonable re-creation of historical phosphorus concentrations. Two empirical models were compared to the forecasting results of MICH1 and TPM. The forecasts generally indicate a steady-state total phosphorus concentration of about 7 μg-P/1, given a target load recommended by the 1978 Water Quality Agreement, which reflects a point source standard. The projected response time by MICH1 is 7-14 years for obtaining 95% of steady-state concentrations.

Ross, M. J., and J. H. McCormick. 1981. Effects of External Radio Transmitters on Fish. Prog. Fish-Cult. 43(2): 67-72. ERL-D Reprint #275.

Yellow perch (Perca flavescens) and largemouth bass (Micropterus salmoides) were studied to determine the effects of externally attached radio transmitter tags. Perch that had been tagged with dummy radio tags were more susceptible to predation and more sensitive to environmental stress than were controls. Feeding and respiration rates were similar among dummy tagged and control groups of perch over a 6-week period. The feeding rate of dummy tagged largemouth bass was lower than that of untagged fish over a 3.5-week period. On the basis of these studies, we conclude that weights of external transmitters in water should be less than 1.5% of the fish weight. Design considerations should include streamlining components and an anterior attachment wire at the extreme leading edge of an external transmitter to prevent entanglement of the tag in surrounding vegetation.

Ross, M. J., and J. D. Winter. 1981. Winter Movements of Four Fish Species Near a Thermal Plume in Northern Minnesota. Trans. Am. Fish. Soc. 110: 14-18.

During winter 1975, 17 yellow perch (Perca flavescens), 6 northern pike (Esox lucius), 3 walleyes (Stizostedion vitreum), and 2 largemouth bass (Micropterus salmoides) were equipped with radio frequency transmitters to compare their winter movements near the thermal plume of a power plant. The mean home range sizes, in hectares, were northern pike 19.0; yellow perch 13.4; largemouth bass 3.7; walleye 2.2. Northern pike and yellow perch had mean home range sizes larger than the discharge area. Mean water depths at fish locations were as follows: largemouth bass 0.8 m; northern pike 1.2 m; yellow perch 1.6 m; walleye 3.5 m. Largemouth bass preferred the warmest locations near the discharge point. Yellow perch were most often located in the peripheral areas of the discharge bay while walleyes were most often located in the deeper center area. Northern pike moved over the entire discharge area. All species except largemouth bass moved freely between discharge-affected and unaltered waters. The average numbers of movements per individual per week between heated and unheated areas were the following: northern pike 0.8; yellow perch 1.2; walleye 1.1; largemouth bass, 0.

Russo, R. C., R. V. Thurston, and K. Emerson. 1981. Acute Toxicity of Nitrite to Rainbow Trout (Salmo gairdneri): Effects of pH, Nitrite Species, and Anion Species. Can. J. Fish. Aquat. Sci. 38: 387-393.

The toxicity of nitrite to rainbow trout is pH-dependent within the range considered acceptable to most freshwater aquatic life (pH 6.5-9.0). Both of the nitrite species, NO_2^- and HNO_2, are toxic. It is recommended that nitrite criteria to protect freshwater aquatic life be based on total nitrite, and that such criteria reflect the pH dependence of nitrite toxicity. Variation in the toxicity of nitrite in the presence of chloride, sulfate, phosphate, and nitrate anions has also been demonstrated. It is also dependent in varying degrees upon many of the anions that are commonly found in natural aquatic environments.

Safe, S., A. Parkinson, L. Robertson, R. Cockerline, and L. Safe. 1981. PCBs as Microsomal Enzyme Inducers: Structure-Activity Rules. IN: Toxicology of Halogenated Hydrocarbons (O. Hutzinger, ed.), pp. 106-119.

A number of highly purified synthetic polychlorinated biphenyl (PCB) isomers and congeners were administered to male Wistar rats to test previously reported structure-activity rules for PCBs as hepatic microsomal drug-metabolising enzyme inducers. By comparing the mode of induction of each PCB with that of the classical inducers phenobarbitone (PB) and 3-methylcholanthrene (MC), the following structure-activity rules were apparent. (1) Structure-activity rules for the induction of

PB-type activity could not be clearly defined due to the structurally-diverse PCB isomers and congeners which fall into this category. (2) PCBs which induce MC-type activity must be substituted in both para positions, at least two meta positions (but not necessarily on different phenyl rings) and can also contain one or two ortho chlorines particularly if one phenyl ring contains a 2,3,4-trichloro substitution pattern.

Twelve PCB congeners (namely 2',3,4,4',5-penta-, 2,3,4,4',5-penta-, 2,3,3',4,4'-penta-, 2,3',4,4',5-penta, 2',3,3',4,4',5-hexa-, 2,3,3',4,4',5-hexa, 2,3,4,4',5,6-hexa-, 2,2',3,3',4,4'-hexa-, 2,2',3'4,4',5-hexa-, 2,3,3',4,4',6-hexa, 2,3,3',4,4',5,5'-hepta- and 2,2',3,3',4,4',5-heptachlorobiphenyl) elicited both PB- and MC-type responses producing a pattern of mixed (PB + MC) induction. Unlike the previously identification MC-type inducers (namely 3,3',4,4'-tetra, 3,3',4,4',5-penta- and 3,3',4,4',5,5'-hexachlorobiphenyl), many of the mixed-type inducers are major or minor components of the commercial PCB preparations (e.g., Aroclor 1254) and must contribute to their activity as MC-type inducers. Since many of the mixed-type PCB inducers exhibit unusually high toxicity, it is possible that these components are major contributors to both the biologic and toxicologic properties of commercial PCB mixtures.

Sicko-Goad, L., and D. Lazinsky. 1981. Accumulation and Cellular Effects of Heavy Metals in Benthic and Planktonic Algae. Micron 22(3): 289-290.

These results suggest that in addition to metal exclusion, two other mechanisms are responsible for successful adaptation to heavy metals in Great Lakes algae. (1) Heavy metals, especially Pb, Cd, and Zn can be incorporated in polyphosphate bodies. Metals incorporated in this manner can be transferred by direct consumption through the food chain as we have demonstrated in the tubificid worm. Mobilization of polyphosphate in phosphorus poor waters could internally mobilize the metal in the same organism, eventually leading to death of the organism or release of the metal to the soluble phase in an area distant from the source of the metal. (2) Heavy metals, though not present in detectable levels in the cells may be immobilized within the cell in vacuoles. In certain organisms, these might be excreted back into the environment or produce cellular changes which may prevent certain organisms from growing and competing successfully in areas where the metals persist, leading to the growth of undesirable species.

Siegel, D. I. 1981. The Effect of Snowmelt on the Water Quality of Filson Creek and Omaday Lake, Northeastern Minnesota. Water Resour. Res. 17(1): 238-242.

Sulfate concentration and pH were determined in surface water, groundwater, and precipitation samples collected in the Filson Creek watershed to evaluate the sources of sulfate in Filson Creek. During and immediately after snowmelt, sulfate concentrations in Filson Creek increased from about 2 to 14 mg/l. Concurrently, H^+ ion activity increased from an average of $10^{-6.6}$ to $10^{-5.5}$. These changes suggest that sulfate acidity is concentrated in the snowpack at snowmelt, which is similar to changes reported in Scandinavia in areas subject to acid precipitation. Mass balance calculations indicate that the sulfate contribution from groundwater during snowmelt was minimal in comparison to that from snow. During base flow, sulfate did not appreciably increase from the headwaters of Filson Creek to the mouth, even though sulfate was as high as 58 mg/l in groundwater discharging to the creek from surficial materials overlying a sulfide-bearing mineralized zone in the lower third of the watershed. Approximately 10.6 kg of sulfate per hectare per year was retained in 1977.

Siegel, D. I. 1981. Effect of Snowmelt on the Quality of Filson Creek and Omaday Lake, Northeastern Minnesota. U.S. Geological Survey, Water-Resources Investigations 81-66, 81 pp.

Concentrations of major constituents were determined in the surface water, ground water, and precipitation in Filson Creek watershed to evaluate the effects of acid precipitation on surface-water quality during snowmelt. Concentrations of sulfate increased in Filson Creek and Omaday Lake during snowmelt from less than 2 to 12 milligrams per liter in 1977 and from less than 2 to 4 milligrams per liter in 1979. Hydrogen-ion activity increased from $10^{-6.5}$ to $10^{-5.0}$ during snowmelt in 1977 and from $10^{-6.5}$ to $10^{-6.0}$ in 1979. The magnitude of the increases of sulfate and hydrogen-ion concentrations depend on the (1) timing of the snowmelt, (2) concurrent precipitation, and (3) antecedent soil-moisture conditions. Alkalinity and concentrations of total calcium, magnesium, and sodium in the creek during snowmelt reflect the simple dilution of streamflow with more dilute precipitation. The mixing process is defined by hyperbolic curves of concentration versus discharge and can be modeled by use of a mass-balance equation. Concentrations of silica and total potassium in the creek during snowmelt are less than that at base flow because of dilution and uptake by diatoms and plants, respectively.

A quality-assurance study was made to determine the accuracy and precision of the turbidimetric, complexometric (methylthymol blue), and ion-chromatographic methods used to determine concentrations of sulfate in water. Results suggest that the ion-chromatographic method is more accurate and more precise in the detection of sulfate at concentrations of 5 milligrams per liter or less. To obtain accuracy with either the turbidimetric or the complexometric methylthymol blue method, color blanks and turbidity should be determined if concentrations of sulfate are expected to be low, such as in precipitation, or where water is colored by organic material. Interference by color and turbidity is not a factor in the ion-chromatographic method.

Spehar, R. L., A. E. Lemke, Q. H. Pickering, T. H. Roush, R. C. Russo, and J. D. Yount. 1981. Effects of Pollution on Freshwater Fish. J. Water Pollut. Control Fed. 53(6): 1028-1076. ERL-D Reprint #251.

A review of the 1981 world literature was conducted on the effects of pollution on freshwater fish. This review contained 376 references and included papers on water quality such as dissolved gases and pH; chemical pollutants such as insecticides, herbicides, piscicides and anesthetics; inorganics, organics and industrial and municipal effluents including chlorine and wastewater and pulp and paper. Papers from reviews and symposia and those dealing with physical factors were also included. Within the above sections, papers were organized into general articles, surveys, toxicology, bioaccumulation, physiology and behavior.

Stevenson, R. J., and E. F. Stoermer. 1981. Quantitative Differences Between Benthic Algal Communities Along a Depth Gradient in Lake Michigan. J. Phycol. 17: 29-36.

This study analyzes the impact of conditions associatd with depth upon benthic algal communities in Lake Michigan. Diatom abundance was greater at 9.1 and 14.6 m depths than 6.5, 22.6 and 27.4 m. Shallow (6.5 m), mid-depth (9.1 and 14.6 m), and deep (22.6 and 27.4 m) zones were distinguishable on the basis of community composition, structure and abundance. Dominance of benthic species, high diversity and low abundance in shallow communities probably resulted from substantial substrate disturbance by wave action in this productive zone. Dominance of benthic species, high diversity and high abundance characterized mid-depth communities where less wave disturbance enabled algal accumulation. Preponderance of living planktonic taxa, low diversity and low abundance delineated deep communities where planktonic algae accumulated and low light levels reduced growth of benthic species.

Stoermer, E. F. 1981. Diatoms Associated with Bryophyte Communities Growing at Extreme Depths in Lake Michigan. Proc. Iowa Acad. Sci. 88(2): 91-95.

Diatom assemblages on limestone cobbles collected from 42.7 m depth in the mid-lake high region of Lake Michigan are characterized by low total abundance and low diversity. The flora present contains three associations. A large allochthonous component, comprised of planktonic species and very low numbers of benthic species usually found in shallow water is present. A limited number of dominant taxa appear to be particularly associated with deep habitats in oligotrophic lakes. Other species, usually reported from terrestrial habitats, appear to be associated with the bryophyte Fissidens fontanis which is present in all collections.

Stoermer, E. F., R. G. Kreis, Jr., and L. Sicko-Goad. 1981. A Systematic, Quantitative, and Ecological Comparison of *Melosira islandica* O. Mull. with *M. granulata* (Ehr.) Ralfs from the Laurentian Great Lakes. J. Great Lakes Res. 7(4): 345-356.

> *Melosira granulata* and *M. islandica* occur sympatrically in the Laurentian Great Lakes, but maximum population abundance of the two species occurs at opposite ends of the range of seasonal and trophic conditions found in the system. Both species are polymorphic, but are distinguishable on the basis of a number of morphological characteristics. Their distribution and the range of morphologic variation encountered in populations from the Great Lakes is summarized and discussed. Although ranges in size and computed cell volumes of populations of the two species overlap, there are significant differences in cellular composition. Cells of *M. islandica* contain a much larger fraction of living cytoplasm and cell wall material than cells of *M. granulata*.

Stout, J. 1981. Photometric Determination of Leaf Input into Tropical Streams. J. Fresh. Ecol. 1(3): 287-293.

> Four methods often used in preparing leaves for studies on the fate of leaves falling into mid-latitude streams were analyzed in a tropical rainforest stream. Both the techniques and plant species affected processing rates for four species of tropical wet forest riparian plants. More leaf area remained for fresh leaf disks than for dried leaf disks. Photometric rather than the usual dry leaf mass measurement techniques were used because, 1) leaves do not have to be dried before they are used, 2) artificially dried leaves do not simulate natural conditions, especially in humid tropical forests, 3) leaves can be measured photometrically and replaced in streams without damaging tissue, 4) photometric methods are commonly used in terrestrial studies on leaf damage and these methods should be equally adaptable to aquatic systems, and 5) the correlation between leaf area loss and dry mass loss for terrestrial studies has been shown to be high; therefore, dry mass data from studies on aquatic leaf decomposition studies are expected to be similar to photometrically-derived leaf area data.

Swain, W. R. 1981. The Great Lakes: An Example of International Cooperation to Control Lake Pollution. GeoJournal 5(5): 447-456.

> The history of international cooperation efforts between the United States of America and Canada to control and abate pollution of the North American Great Lakes began in the early 1900's. The more than seventy years of joint efforts fall into three phases: 1) an early concern with bacterial contamination, 2) an intermediate era dealing with eutrophication issues, and 3) the current period in which residue forming toxic substances of anthropogenic origin are of chief concern.

The magnitude of the problem and complex arrangement of jurisdictions mandated a concerted effort of both countries to find the solutions for the preservation of their boundary waters. Combined activities toward pollution control have resulted in a number of positive accomplishments in the reduction of phosphorus concentrations, and in future management issues relative to toxic xenobiotic substances. It is evident that the only effective solution to the problem lies in continued international cooperation.

Swain, W. R. 1981. Ecosystem Monitoring in the Great Lakes: Research Needs, Public Health Implications. Great Lakes Focus on Water Quality. International Joint Commission 7(1): 1-2, 8-12.

This article is an edited version of an address before the Great Lakes Pollution Monitoring Workshop sponsored by the National Oceanic and Atmospheric Administration (NOAA) in Ann Arbor, Michigan, February 11-12, 1981. Current and historical efforts in Great Lakes monitoring are reviewed. The contributions of the Great Lakes Information and Surveillance Plan (GLISP) to existing knowledge of the ecosystem are discussed. An ecosystem approach to toxic substances in the Great Lakes is presented and recommendations for implementing the surveillance plan for consideration of toxic organic substances are made.

Swain, W. R. 1981. Ecology, Superior. Horizons 3(3): 6-7.

This article compares the ecology, geology, physical characteristics and uses of Lake Superior in North America and Lake Baikal in the USSR.

Theriot, E., and E. F. Stoermer. 1981. Some Aspects of Morphological Variation in *Stephanodiscus niagarae* (Bacillariophyceae). J. Phycol. 17: 64-72.

Valves of *S. niagarae* var. *niagarae* Ehr. and *S. niagarae* var. *magnifica* Fricke from geographically dispersed sediment and plankton collections were observed by light microscopy and scanning electron microscopy (LM and SEM). Measurements made by LM can be arranged so that means and ranges of diameter, areolar density, or strial density intergrade from one population into the next. Mean diameter is negatively related to increasing areolar and strial densities. No unique features observable by SEM distinguish the two described varieties. Thus, *S. niagarae* var. *magnifica*, having large diameter valves with low areolar and strial densities, may represent one end of a trend in overall varaition in *S. niagarae*. At the opposite extreme are the populations with small valves and high areolar densities which are often erroneously referred to as *S. astraea*. Type material of *S. niagarae* lies intermeidate to these forms. Three populations considered in this study have distinct morphological characteristics. Valves from Yellowstone Lake sediments have spine placements distinctly different from valves of all other populations. Specimens from Lake Superior have nearly flat central areas. Ribs of valves from Grand Traverse Bay (Lake Michigan) are covered with granules.

Thomann, R. V. 1981. Equilibrium Model of Fate of Microcontaminants in Diverse Aquatic Food Chains. Can. J. Fish. Aquat. Sci. 38: 280-296.

Bioconcentration and bioaccumulation factors of PCB, ^{239}Pu, and ^{137}Cs are compiled from the literature as a function of organism size. The distribution of field-observed bioaccumulation factors varies markedly between each substance but similary to order of magnitude within each substance across diverse food chains. It can be inferred from the literature that PCB levels in top predators are due primarily to food chain transfer. A steady state compartment food chain model is derived for estimation of the relative effect of uptake directly from water versus food chain transfer. The model food chain transfer number f, given by $\alpha C/K + G$ for α = chemical absorption efficiency, C = specific consumption, K = excretion rate, and G = net organism growth rate indicates the degree of food chain accumulation. For $f > 1$, food chain transfer is significant; for $f < 1$, uptake from water is more significant. Application of the model suggests that (a) PCB body burden in top predators is due almost entirely to consumption of contaminated prey, (b) for ^{239}Pu all of the body burden is due to uptake from the water only, and (c) observed ^{137}Cs concentration factors are due principally to food chain transfer with a high dependence on the salinity-dependent phytoplankton adsorption.

Thomas, N. A. 1981. Ecosystem Changes in Lakes Erie and Ontario. IN: Proceedings of the Conference on Changes in the Biota of Lakes Erie and Ontario, Bulletin of the Buffalo Society of Natural Sciences 25(4): 1-20.

All of the Great Lakes are changing; however, the lower lakes because of their increased productivity, are changing at a much faster rate. This condition is reflected in the overall nutrient and biomass content of the individual lakes. The nutrient concentrations of the lower lakes are 4-8 times higher than those in the upper lakes. The increase in phosphorus in the lower lakes has resulted in dramatic increases in phytoplankton biomass, as well as in shifts in the biomass to a greater percentage of bluegreen algae.

Changes have occurred in the zooplankton communities. Here, again, the biomass increases to match the increase in phytoplankton; however, there is also an increase in the more eutrophic taxa. The relative change in the percent calanoid zooplankton population in the lower lakes indicates the severity of the productivity problem in Lakes Erie and Ontario.

Changes in the biota of a lake can result from three major types of influences. The first is change in the physical environment. The second type of change is associated with direct toxicity. There is very little evidence to suggest that this has occurred in Lakes Erie and Ontario. The third type of influence, and, probably, the most prevalent today, are changes resulting from altered food supplies.

The large phytoplankton blooms that were associated with the degradation of Lake Erie were often noted in the late 1960's. These populations have been recorded on a decreasing frequency in the last five years. Some positive changes have occurred since 1972; a decrease has occurred in phosphorus concentrations in Lake Ontario. In the nearshore area adjacent to Toronto, Canada, the decrease has been most dramatic.

During the period since the last conference at Buffalo, the primary concern has shifted from eutrophication and changing fish stocks to contamination of fish and birds with heavy metals and toxic organic substances, as well as a concern for public health. Even though the Lake Ontario ecosystem can support a limited fish population, contamination of the fish with mirex has greatly impaired the use of the fishery.

Thurston, R. V., C. Chakoumakos, and R. C. Russo. 1981. Effect of fluctuating exposures on the acute toxicity of ammonia to rainbow trout (Salmo gairdneri) and cutthroat trout (S. clarki). Water Res. 15: 911-917.

Acute toxicity bioassays in which fish were exposed to short-term cyclic fluctuations of ammonia were conducted on rainbow trout (Salmo gairdneri) and on cutthroat trout (S. clarki). Companion tests were also conducted in which test fish were subjected to ammonia at constant concentrations. The tests ranged in duration from 96 h to 4 weeks. Median lethal concentration (LC50) values in terms of both average and peak concentrations of ammonia for the fluctuating concentration tests were compared with LC50 values for the constant concentration (conventional) tests. Based on comparisons of total dose exposure, results showed that fish were more tolerant of constant concentrations of ammonia than of fluctuating concentrations. Fish subjected to fluctuating concentrations of ammonia at levels below those acutely toxic were subsequently better able to withstand exposure to higher fluctuating concentrations than fish not previously so acclimated.

Thurston, R. V., G. R. Phillips, R. C. Russo, and S. M. Hinkins. 1981. Increased Toxicity of Ammonia to Rainbow Trout (Salmo gairdneri) Resulting from Reduced Concentrations of Dissolved Oxygen. Can. J. Fish. Aquat. Sci. 38(8): 983-988.

The median lethal concentration (LC50) of aqueous ammonia at reduced dissolved oxygen (D.O.) concentrations was tested in acute toxicity tests with rainbow trout (Salmo gairdneri) fingerlings. Fifteen 96-h flow-through tests were conducted over the D.O. range 2.6-8.6 mg/l, the former concentration being the lowest at which control fish survived.

There was a positive linear correlation between LC50 (milligrams per liter un-ionized ammonia) and D.O. over the entire D.O. range tested; ammonia toxicity increased as D.O. decreased. Ammonia LC50 values were also computed for 12, 24, 48, and 72 h; the correlation with D.O. was greater the shorter the time period.

Thurston, R. V., R. C. Russo, and G. A. Vinogradov. 1981. Ammonia Toxicity to Fishes. Effect of pH on the Toxicity of the Un-ionized Ammonia Species. Environ. Sci. Technol. 15(7): 837-840.

United States and European water quality criteria to protect aquatic life assume that the toxicity of aqueous ammonia is attributable to the un-ionized (NH_3) chemical species, and that the ionized (NH_4^+) species is non-toxic or significantly less toxic than NH_3. Data are presented here on the toxicity of ammonia to rainbow trout (Salmo gairdneri) and to fathead minnows (Pimephales promelas) from two series of 96-h flow-through toxicity tests in which pH was controlled within the range 6.5-9.0. Results show that the toxicity of ammonia in terms of NH_3 increased at lower pH values. It is concluded that NH_4^+ exerts some measure of toxicity and/or that increased H^+ concentration increases the toxicity of NH_3. It is recommended that water quality criteria be revised to consider the pH dependence of the toxicity of ammonia.

Veith, G. D., and D. W. Kuehl. 1981. Automated Gel-Permeation System for Removal of Lipids in Gas Chromatography/Mass Spectrometric Analysis of Fatty Tissues for Xenobiotic Chemicals. Anal. Chem. 53: 1132-1133. ERL-D Reprint #248.

The interference of natural lipids in gas chromatography/mass spectrometric analysis of xenobiotic chemicals in fatty tissue can be substantially reduced using gel-permeation chromatographic removal of the lipids. This paper presents an inexpensive controller which can be used with any manual gel-permeation system to automate the isolation of trace chemicals from lipids. The controller is especially suited for the preparation of large samples required for gas chromatography/mass spectrometric identification of its trace contaminants.

Veith, G. D., D. W. Kuehl, E. N. Leonard, K. Welch, and G. Pratt. 1981. Polychlorinated Biphenyls and Other Organic Chemical Residues in Fish From Major United States Watersheds Near the Great Lakes, 1978. Pestic. Monitor. J. 15(1): 1-8. ERL-D Reprint #257.

> Twenty-six composite samples of fish were collected during 1978 from United States watersheds near the Great Lakes and analyzed for polychlorinated biphenyls (PCBs) and related organic chemicals. PCB mixtures resembling Aroclor 1254 were found in all samples, and mixtures resembling Aroclor 1242 (or 1016) were found in 77 percent of the samples. Total PCB concentrations in the whole-fish composite samples ranged from 0.13 to 14.6 ppm; 65 percent of the samples contained >2 ppm PCBs. DDT and its metabolites were also found in all samples. DDT concentration was 1.66 ppm, and 81 percent of the samples contained <1.0 ppm DDT. Chlordane ranged from <0.001 to 2.57 ppm in 38 percent of the samples. Hexachlorobenzene was found in 65 percent of the samples, ranging from <0.005 to 0.447 ppm. Other chemicals identified by gas chromatography/mass spectrometry included petroleum hydrocarbons and chlorobenzenes, chlorostyrenes, chlorophenols, and chlorinated aliphatic compounds. Fish from the Ashtabula River (Ohio), Rocky River (Ohio), and Wabash River (Indiana) contained extremely complex residues of chlorinated and other organic chemicals.

Welch, K. J., D. W. Kuehl, E. N. Leonard, G. D. Veith, and N. D. Schoenthal. 1981. Background Hydrocarbon Residues in Fishes from the Great Lakes and Eastern Montana. Bull. Environ. Contam. Toxicol. 26: 724-728. ERL-D Reprint #249.

> For the past eight years, this laboratory has been conducting GC/MS exploration studies of organic chemical residues in fishes from major U.S. watersheds. One of the frequently occuring classes of chemicals isolated by multi-class analytical techniques, such as gel permeation chromatography, is *n*-alkanes. Odd-numbered alkanes with 13-19 carbon atoms are often the most abundant, and are predominanted by *n*-heptadecane. The presence of these compounds seem to indicate normal biosynthesis in aquatic ecosystems, whereas their absence or the presence of other hydrocarbon mixtures which obscure the natural hydrocarbons may be indicative of an adverse impact on the ecosystem.
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> This study presents quantitative data for background levels of these compounds in fishes from selected eastern Montana watersheds. Sampling sites were chosen to represent watersheds having coal extraction and conversion activities and those that do not. In comparison, data are also presented for Great Lakes fish.

Zinnel, K. C., M. J. Ross, and V. B. Kuechle. 1981. An Automatic Fish Tracking System for the U.S. E.P.A.'s Monticello Ecological Research Station. Underwater Telemetry - Tracking Aquatic Animals Newsletter 11(1): 9.

An automatic tracking system controlled by an RCA 1802 microprocessor was developed to locate fish in a 400 m outdoor experimental stream channel at the U.S. EPA Monticello Ecological Research Station. The monitoring network consisted of 12 horizontally polarized antennas spaced at 30 m intervals. The antennas were sequentially switched into a receiver and the signal strength at each antenna was measured. The microprocessor controlled all timing, switching and measurement functions. Each fish tracked by the system was tagged with an implanted radio transmitter which had a unique frequency in the 53 MHz band. Selecting a particular fish for tracking was equivalent to requesting a particular frequency entered into the memory of the receiver. The microprocessor determined which antenna had the maximum signal level and printed this information along with fish number and time of day. Also, to give an estimate of data quality, a signal to noise index was calculated by subtracting an estimate of the background noise from the signal level obtained from the antenna closest to the fish.

EPA RESEARCH REPORTS

Bahnick, D. A., W. A. Swenson, T. P. Markee, D. J. Call, C. A. Anderson, and R. T. Morris. 1981. Development of Bioassay Procedures for Defining Pollution of Harbor Sediments. Part I. U.S. Environmental Protection Agency, Duluth, Minnesota, Publication No. EPA-600/3-81-025. 196 pp. Project Summary No. EPA-600/S3-81-025.

This research investigates bioassay methods which may be useful in assessing the degree of pollution of harbor sediments. Procedures studied include 96-hr toxicity tests employing Hexagenia limbata, Daphnia magna, and Pontoporeia affinis as biological probes, monitoring cough frequencies of bluegill sunfish (Lepomis macrochirus) in interstitial water derived from sediments, chemical analyses of sediment-water systems, and chemical analysis of chironomids and Hexagenia limbata exposed to the sediments. Additional experiments involved investigation of the degree of removal of chemical constitutents from sediments due to extraction with Lake Superior water and the use of reverse phase liquid chromatography in detecting the presence of chemical compounds with high bioaccumulation potential in the sediments.

A general toxicity index was prepared from the chemical data which indicated that animal survival in the 96-hr acute toxicity tests was generally lower using sediment systems from the more industrialized areas of the harbor.

Benoit, D. A. 1981. User's Guide for Conducting Life-Cycle Chronic Toxicity Tests with Fathead Minnows (Pimephales promelas). U.S. Environmental Protection Agency, Duluth, Minnesota, Publication No. EPA-600/8-81-011. 17 pp.

> This paper represents a revised procedural guide for conducting life-cycle chronic toxicity tests with fathead minnow (Pimephales promelas). These new procedures are based on recent evaluations of published toxicity tests and methods used by aquatic toxicologists to conduct life-cycle chronic tests and early life stage tests with fathead minnows. These published papers are referenced in the appropriate place throughout the text of this report. If more detailed information on test apparatus or specific biological and chemical methods is desired, the reader is encouraged to study the reference material.

Cairns, J., Jr., K. W. Thompson, and A. C. Hendricks. 1981. Effects of Fluctuating, Sublethal Applications of Heavy Metal Solutions upon the Gill Ventilation Response of Bluegills (Lepomis macrochirus). U.S. Environmental Protection Agency, Duluth, Minnesota, Publication No. EPA-600/3-81-003. 101 pp. Project Summary No. EPA-600/S3-81-003.

> The ventilatory response of the bluegill to fluctuating, sublethal amounts of heavy metals was investigated. Non-contact submerged, stainless steel electrodes were used to detect the weak electrical potentials that are produced when fish ventilate their gills. These signals were amplified using high-gain amplifiers which were interfaced with a minicomputer. These ventilatory data were accumulated continuously, and both the ventilatory rates and average signal amplitudes were recorded on electronic tape for later analysis.
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> The response to these toxic solutions was an increase in rate as well as a decrease in signal amplitude. The latter response was shown to be a real response of the fish and not due to changes in the electrical properties of the water when toxicant was added. Due to the extreme smoothing of the data, the analysis of variance was unable to detect any differences between the toxicant application patterns. It was significant to note, however, that the fish were capable of reacting to each subsequent pulse of toxicant in a similar manner.

Cary, G. A., and M. E. Barrows. 1981. Reduction of Toxicity to Aquatic Oganisms by Industrial Wastewater Treatment. U.S. Environmental Protection Agency, Duluth, Minnesota, Publication No. EPA-600/3-81-043. 70 pp. Project Summary No. EPA-600/S3-81-043.

> The specific goal of this research was to conduct 24-hour static acute bioassays with "untreated" influent and "treated" effluent using fathead minnows (Pimephales promelas) and water flea (Daphnia magna) to biologically evaluate the effectiveness of industrial wastewater facilities in reducing effluent toxicity to aquatic organisms. Of primary interest to the EPA was an evaluation of the capacity of the

wastewater treatment facilities of the pesticide industry for reducing toxicity. To accomplish the stated goal, on-site 24-hour static acute toxicity tests were performed during ten consecutive workdays at seven industrial sites. Five of the test sites were defined as pesticide manufacturers, while the remaining sites consisted of an organo-chemical manufacturer and a bleached-kraft paper mill. The effectiveness of the treatment plants was determined by performing static acute toxicity tests with the fathead minnow (Pimephales promelas) and the water flea (Daphnia magna) on samples of the wastewater collected before and after treatment. Results of the studies are expressed in terms of both median concentrations (LC50's) as percent effluent and lethal units.

The data from these studies indicate that the wastewater treatment plants provided an average efficiency of 98% in reducing the toxicity of "untreated" wastewaters. Neither species tested proved to be a more sensitive indicator of toxicity, though a larger data base is required to make valid appraisal.

Of interest was the observation that while some wastewater treatment facilities provide good efficiency (98±%) in reducing toxicity, the resulting effluent still represented a relatively high number of lethal units. This was a result of the fact that the "untreated" influent entering the waste treatment system contained a very high level of lethal units and a subsequent 98% reduction of that level still resulted in a toxic wastewater.

Dave, G. 1981. Influence of Diet and Starvation on Toxicity of Endrin to Fathead Minnows (Pimephales promelas). U.S. Environmental Protection Agency, Duluth, Minnesota, Publication No. EPA-600/3-81-048. 85 pp. Project Summary No. EPA-600/S3-81-048.

Endrin toxicity to fathead minnows, Pimephales promelas, was determined in flow-through toxicity tests at 25°C for periods of up to 30 days.

Three months prior to endrin exposure, six groups of fish were fed artificial diets containing an increasing percentage of fat, and two groups were fed either a high or low ration of frozen brine shrimp. Fish fed frozen brine shrimp showed better growth, survival and fewer deformities (hemorrhagic kidney lesions and lordosis) than fish fed artificial diets. Based on 96-hr LC50 values, fish fed diets low in dietary fat were 2.4 times more susceptible to endrin than fish fed frozen brine shrimp. On the same basis (96-hr LC50) fish fed a low ration level of brine shrimp were 2.0 times more susceptible to endrin than fish fed an unrestricted ration level of brine shrimp.

In another series of experiments, adult fathead minnows starved for 80 days were 2.0 times more susceptible to endrin than recently fed fish. Fathead minnows captured in a small pond on April 30 were also about 2.0 times more susceptible than recently fed fish. There was no detectible relationship between body weight and susceptibility of fathead minnows to acute endrin toxicity.

The reduced tolerances to endrin caused by a low percentage of dietary fat, reduced ration level, and starvation were correlated to an increased total body water content. The underlying reason is assumed to be a concomitantly decreased total body lipid content.

DiToro, D. M., J. J. Fitzpatrick, and R. V. Thomann. 1981. Documentation for Water Quality Analysis Simulation Program (WASP) and Model Verification Program (MVP). U.S. Environmental Protection Agency, Duluth, Minnesota, Publication No. EPA-600/3-81-044. 145 pp.

A generalized water quality modeling program and a model verification analysis program have been developed that have application to a wide variety of water resource management problems. The Water Quality Analysis Simulation Program, WASP, is based on the flexible compartment approach. It may be applied to water bodies in a one, two, or three-dimensional configuration, and kinetic models may be structured to include linear and non-linear reactions. The user may choose, via input options, to employ constant or time-variable transport and kinetic processes, as well as point and non-point waste discharges. The Model Verification Program, MVP, may be used as an indicator of "goodness of fit" or adequacy of the model as a representation of the real world.

To date, WASP has been applied to over twenty water resource management problems. These applications have included one, two and three-dimensional configurations and a number of different physical, chemical and biological modeling frameworks, such as BOD-DO, eutrophication, and toxic substances.

A user's manual and program listings have been prepared. The user's manual was oriented towards the system analyst, whose responsibility it would be to design, develop and debug new kinetic models for end users, as well as the end user who must prepare the data input to the program.

Kosian, P., A. Lemke, K. Studders, and G. Veith. 1981. The Precision of the ASTM Bioconcentration Test. U.S. Environmental Protection Agency, Duluth, Minnesota, Publication No. EPA-600/3-81-022. 21 pp. Project Summary No. EPA-600/S3-81-022.

The ASTM method for measuring the bioconcentration factor (BCF) of chemicals was evaluated using 1,2,4-trichlorobenzene (TCB), hexachlorobenzene (HCB), and p,p'-DDE (DDE). Four replicate, 28-day exposures of the chemicals to the fathead minnows were used to determine the precision of the test method. Using the 28-day values, the mean (±S.D.) BCF for TCB, HCB, and DDE were 1,700 (±70), 35,000 (±3,300), and 50,000 (±4,800), respectively. The results showed that steady-state residues are not attained for highly bioaccumulative chemicals in the 28-day exposure and the calculation of the BCF by dividing the 28 day residues by the mean water concentration is inadequate. Two alternate methods of calculating the BCF are discussed.

Lemke, A. E. 1981. Interlaboratory Comparison: Acute Testing Set. U.S. Environmental Protection Agency, Duluth, Minnesota, Publication No. EPA-600/3-81-005. 26 pp. Project Summary No. EPA-600/S3-81-005.

> A multiple laboratory (6) set of tests was conducted using a single Test Standard Method. The tests consisted of static and dynamic aquatic bioassays with two species of fish and static tests with Daphnia magna in duplicate. The extreme values for any one test were one order of magnitude while the extremes of the means were only a factor of 2.

Matisoff, G., J. B. Fisher, and W. Lick. 1981. Early Diagenesis and Chemical Mass Transfer in Lake Erie Sediments. U.S. Environmental Protection Agency, Duluth, Minnesota, Publication No. EPA-600/3-81-046. 183 pp. Project Summary No. EPA-600/S3-81-046.

> Vertical profiles of pore water and sediment solids chemistry were obtained from two sites in Lake Erie. Samples were collected using both gravity coring and pore water "peeper" techniques. In general, concentrations of nutrients and toxic metals in sediment solids decreased with increasing depth. Comparison of pore water "peeper" data to gravity core data showed that "peeper" data provides higher resolution near the sediment-water interface. The thermodynamic tendency of metal phosphate and carbonate mineral phases to precipitate in Lake Erie sediments has been calculated by means of an ion-pair model of the interstitial water chemistry. The calculations suggest that detrital calcite, aragonite, and dolomite should be dissolving in the sediments, but that iron and manganese carbonates should be precipitating. Regenerated phosphate should be reacting with calcium, iron, manganese, and lead to form authigenic mineral phases. Whitlockite ($Ca_3(PO_4)_2$) and not hydroxylapatite ($Ca_5(PO_4)_3OH$) is the predicted mineral phase controlling phosphate solubility. Rates of anaerobic decomposition of Lake Erie sediments from one locality were determined for seven depth intervals at three temperatures. Concentration increases of bicarbonate, phosphate, ammonium, calcium, magnesium, iron, and manganese in pore water within any given depth interval followed zeroth order kinetics and exhibited Arrhenius temperature dependency. The observed release rates decrease exponentially with depth in the sediment due to a corresponding decrease in the amount of oxidizable organic matter and acid hydrolyzable mineral phases.

Spacie, A., A. G. Vilkas, G. F. Doebbler, W. J. Kuc, and G. R. Iwan. 1981. Acute and Chronic Parathion Toxicity to Fish and Invertebrates. U.S. Environmental Protection Agency, Duluth, Minnesota, Publication No. EPA-600/3-81-047. 79 pp.

> Acute and chronic aquatic bioassays were conducted with a variety of aquatic organisms using parathion [0,0-diethyl 0-(p-nitrophenyl) phosphorothioate] as the challenge compound. The bioassay organisms challenged to this study and their resultant 96-hour LC50 values were:

bluegill sunfish, *Lepomis macrochirus* Rafinesque, 0.51 mg/l; brook trout, *Salvelinus fontinalis* (Mitchill), 2.00 mg/l; fathead minnow, *Pimephales promelas* Rafinesque, 1.6 to 0.5 mg/l; water flea, *Daphnia magna* Straus, 0.63 μg/l; scud, *Gammarus fasciatus* Say, 0.4 μg/l; and midge, *Chironomus tentans* (Fabricius), 31.0 μg/l. Non-lethal effects such as deformities and acetylcholinesterase depression were documented in bluegill chronically exposed for 23 months to parathion concentrations in excess of 0.17 μg/l. Adult brook trout exhibited no toxic symptoms at 7.2 μg/l parathion exposure but egg hatchability was reduced at an exposure concentration of 32 μg/l. Chronic exposure of the fathead minnow to a parathion concentration of 4 μg/l for 8-1/2 months resulted in adult deformities and decreased egg production. Parathion residues detected in exposed bluegills were 5 to 25 times that of the exposure water while trout exhibited a bioconcentration of several hundred times that of exposure water. Parathion residues in the fathead minnow were detected as intermediate between bluegill and trout. Juvenile and adult stages of chronically exposed fish appeared to be the most sensitive to parathion. The chronic no-ill-effect concentration for *D. magna* was 0.08 μg/l, for *G. fasciatus* it was less than 0.04 μg/l and for *C. tentans* it was less than 3.1 μg/l. Mean LC50 concentrations for *D. magna* (48-hour) and *G. fasciatus* (96 hour) were 1.13 μg/l (n = 2) and 0.39 μg/l (n = 4) respectively.

Stefan, H. G., J. Gulliver, A. Y. Fu, and M. G. Hahn. 1981. Water Temperature Dynamics in Experimental Field Channels: Analysis and Modeling. U.S. Environmental Protection Agency, Duluth, Minnesota, Publication No. EPA-600/3-81-008. 188 pp. Project Summary No. EPA-600/S3-81-008.

This study is on water temperature dynamics in the shallow field channels of the U.S. EPA Monticello Ecological Research Station (MERS). The hydraulic and temperature environment in the MERS channels was measured and simulated to provide some background for several biological studies at the Research Station, including one on the effects of artificially high water temperatures on fish and invertebrate populations. An analysis of the temperature measurement problem, the channel temperature regime, microhabitat conditions, and temporal and spatial water temperature dynamics was essential for the investigation. The results of this study are also applicable to the study of temperature dynamics in thermally polluted shallow streams, to the design of canals for cooling water disposal, and to the study of natural water temperature regimes of small streams.

A dynamic stream temperature simulation model MNSTREM with a 3 hour time resolution was developed and verified to give predictions with a standard error of only 0.2 to 0.3°C between measurements and predictions. A data bank of 3-hour water temperature data was developed and analyzed statistically. A wind speed function, $Wftn = 0.0096 (\Delta\Theta_v)^{1/3} + 0.0083 W_2$, essential for the correct prediction of water temperature, was developed from on-site meteorological and water temperature data. In this formula W_2 is the windspeed at 2 m and $\Delta\Theta_v$ represents a virtual temperature difference. Longitudinal dispersion in the channels was measured. Heat transfer into the bed material below the pools of the experimental channels was measured. A computer simulation program, TSOIL, to predict the unsteady water temperature distribution in the three-layered system was also developed.

Veith, G. D. 1981. State-of-the-Art of Structure Activity Methods Development. U.S. Environmental Protection Agency, Duluth, Minnesota, Publication No. EPA-600/3-81-029. 116 pp. Project Summary No. EPA-600/S3-81-029.

The overall objective of this project is to provide the Agency with the technical basis for estimating the toxicity and environmental behavior of organic chemicals from molecular structure. The project is directed toward the evaluation of quantitative structure-activity relationships (QSAR) for use by EPA Program Offices and toward the development of new data and QSAR methods to extend the technique to meet Agency needs.

Specifically, the objective of the Structure-Activity Project is to develop methods to predict the toxicity, persistence, and treatability of large numbers of untested chemicals using QSAR based on structural, chemical, and biological properties of representative reference data bases. Development of QSAR is being tailored for use in the (1) initial screening of chemicals under TSCA, (2) development of risk assessment strategies, (3) prioritization of chemicals for Water Quality Criteria development, and (4) the optimization of national monitoring programs for toxic chemicals.

This report summarizes the progress during the first six months of the project. The report provides a literature review and perspective for applying structure-activity methods to aquatic toxicity of industrial chemicals. Experimental work centered on developing methods for estimating molecular descriptors such as log P and connectivity indexes and on the development of a systematic structure-activity data base for aquatic toxicity. A new program for entering structures into a computer and calculating connectivity indexes is discussed. A general model for predicting 96-hour LC50 for narcotic chemicals is presented.

Weber, T. W. 1981. Response of Phytoplankton to Acidification in Experimental Streams. U.S. Environmental Protection Agency, Duluth, Minnesota, Publication No. EPA-600/3-81-042. 49 pp. Project Summary No. EPA-600/S3-81-042.

In order to examine the response of stream phytoplankton communities to acidification, three artificial streams along the Mississippi River were sampled at biweekly intervals. This study took place at Monticello, Minnesota, during late spring-early summer, 1979. One stream served as a control with an ambient pH of 8.1, and two streams were maintained at pH 6.3 and 5.3 by the addition of sulfuric acid. The streams provided a unique replicate system whereby physical and chemical parameters could be controlled and continually monitored in a field situation. The phytoplankton samples were filtered onto membrane filters and the constituent phytoplankton species were enumerated. The diversity of phytoplankton was similar throughout all three pH regimes. However, phytoplankton community similarity decreased over the course of the six week experimental period. Biomass, measured by *in vivo* chlorophyll fluorescence and as the density of the algal cells, showed a similar pattern. The pattern of algal community development differed across the pH treatments. The phytoplankton at pH 6.3 and 8.1 attained their maximum biomass during the first month of sampling (June). There is a lag in the population maxima of phytoplankton at pH 5.3, possibly due to a slower division rate caused by a less than ideal pH environment. Species composition was nearly identical across the pH range, dominated by diatoms in each stream. The most extreme pH value, pH 5.3, seemed to be a sublethal value for the diatoms existing there.

1982

JOURNAL ARTICLES, BOOK CHAPTERS, PROCEEDINGS, ETC.

Adams, D. D., G. Matisoff, and W. J. Snodgrass. 1982. Flux of Reduced Chemical Constituents (Fe^{2+}, Mn^{2+}, NH_4^+ and CH_4) and Sediment Oxygen Demand in Lake Erie. Hydrobiologia 92: 405-414.

Sediment pore water concentrations of Fe^{2+}, Mn^{2+}, NH_4^+ and CH_4 were analyzed from diver-collected cores and an in situ equilibration device (peeper) in Lake Erie's central basin. Sediment oxygen demand (SOD) was measured at the same station with a hemispheric chamber (including DO probe and recorder) subtending a known area of sediments. The average SOD was 9.4 mM m^{-2} day^{-1} (0.3 g m^{-2} day^{-1}). From pore water gradients within the near-surface zone, the chemical flux across the interface was calculated indirectly using Fick's first law modified for sediments. These calculations, using core and peeper gradients, always showed sediment loss to overlying waters, and variations between the two techniques differed by less than an order of magnitude for Fe^{2+} and CH_4. The transport of these reduced constituents can represent a sizeable oxygen demand, ranging from less than 1% for Fe^{2+} and Mn^{2+} to as high as 26% for NH_4^+, and 30% for CH_4. The average flux of these constituents could account for about a third of the SOD at the sediment-water interface of this station.

Anderson, M. L., C. P. Rice, and C. C. Carl. 1982. Residues of PCB in a Cladophora Community Along the Lake Huron Shoreline. J. Great Lakes Res. 8(1): 196-200.

PCB residues were measured in samples of Cladophora, Ulothrix, net plankton, water, and fish collected in the Harbor Beach area of Lake Huron. The average concentrations of total PCB in each of the sample groups were as follows: water - 0.154 ng/g; Cladophora - 92 ng/g; Ulothrix - 126 ng/g; net plankton - 1,651 ng/g; and fish - 40 to 4,400 ng/g. The PCB patterns in the samples were found to match a mixture of Aroclor 1242 and 1254. Aroclor 1242 represented about 60% of the mixture in all the samples except the fish, where Aroclor 1242 represented about 75% of the total PCB measured. The accumulation factors observed in the progression from Cladophora to net plankton to fish were 1:15:30; these were similar to the concentration factors (1:14:44) developed on these ecosystem compartments in Lake Ontario during the 1972 IFYGL program.

Anderson, R. L. 1982. Toxicity of Fenvalerate and Permethrin to Several Nontarget Aquatic Invertebrates. Environ. Entomol. 11(6): 1251-1257. ERL-D Reprint #291.

> Selected species of stoneflies, caddisflies, mayflies, dipterans, amphipods, and snails were exposed, in the laboratory, to fenvalerate or permethrin in a flowing-water test system for up to 28 days. Both behavior and death were monitored during the exposure. The LC50 values decreased with increasing exposure time. Behavior changes or death were seen at concentrations as low as 0.022 μg/l for fenvalerate and 0.030 μg/l for permethrin. In the fenvalerate exposures, amphipods were the most sensitive, followed by the insects and snails. In the permethrin exposures, changes in normal behavior occurred within hours, but death did not exceed 50% until at least 14 days of exposure. Pesticide accumulation was determined in fenvalerate-exposed snails and permethrin-exposed stoneflies. The range of accumulated fenvalerate in snails was 177 to 1,286 times greater than water concentration. The stoneflies' concentration factor for permethrin ranged from 43 to 570.

Arthur, J. W., J. A. Zischke, and G. L. Erickssen. 1982. Effect of Elevated Water Temperature on Macroinvertebrate Communities in Outdoor Experimental Channels. Water Res. 16: 1465-1477. ERL-D Reprint #280.

> Macroinvertebrates were sampled monthly from December 1976 to September 1977 in two 520 m long outdoor experimental channels. One channel was maintained at ambient seasonal Mississippi River water temperatures and the other 10°C higher. Maximum water temperature reached 31.0°C in the ambient and 40.8°C in the heated channel. Elevated temperature seasonally altered macroinvertebrate abundance and life history in the channels. Few animals were found in the heated channel during the period of maximum water temperature. Most macroinvertebrate density and composition differences were confined to the channel riffles rather than the pools. Peak total density in the heated channel riffles occurred 3 or 4 weeks before the ambient channel. Total macroinvertebrate density was appreciably higher in the heated channel riffles during the winter and spring months and in the ambient channel riffles during the summer months. This seasonal alteration was due to composition differences of several identified taxa. Reproductive periods for one snail and one isopod species began approximately 2 and 3 months earlier in the heated channel than in the ambient channel. No marked change occurred in the reproductive activities of an amphipod in the two channels.

Auer, M. T., and R. P. Canale. 1982. Ecological Studies and Mathematical Modeling of Cladophora in Lake Huron: 2. Phosphorus Uptake Kinetics. J. Great Lakes Res. 8(1): 84-92.

> Laboratory experiments were conducted with field populations of Cladophora glomerata to examine the phosphorus uptake process. Results from 35 experiments conducted over two field seasons emphasize the

importance of two factors in regulating phosphorus uptake: dissolved phosphorus concentration and internal phosphorus pool size. The phosphorus uptake rate increases as dissolved phosphorus availability increases. Negative feedback on uptake rate by internal phosphorus pool size reduces the maximum phosphorus uptake rate as internal pools approach saturation. The absolute maximum phosphorus uptake rate for Cladophora was 4.5%P/day. Values for the half-saturation constant for uptake varied with internal phosphorus pool size and ranged between 30 and 250 μgP/l. The data were fit to published mathematical expressions which describe uptake as a function of internal and external phosphorus levels. The expressions may be used in mathematical models simulating the growth of Cladophora.

Auer, M. T., and R. P. Canale. 1982. Ecological Studies and Mathematical Modeling of Cladophora in Lake Huron: 3. The Dependence of Growth Rates on Internal Phosphorus Pool Size. J. Great Lakes Res. 8(1): 93-99.

The relationship between growth rate and internal phosphorus pool size was examined using field populations of Cladophora golmerata from Lake Huron. Algal samples, representing a range of internal phosphorus concentrations, were harvested from the lake and used for laboratory measurements of growth. Rates of net photosynthesis and respiration were measured under controlled conditions of light and temperature using a dissolved oxygen (light/dark bottle) technique. The net specific growth rate and respiration rate were calculated from photosynthesis and respiration measurements using a fixed stoichiometric relationship and the measured carbon content of the algae. The maximum rates for net specific growth rate, gross specific growth rate, and specific respiration rate were 0.77, 1.08, and 0.44 day^{-1}, respectively. Management decisions may be importantly influenced by the relationships derived from these data. A non-linear response by growth to reductions in phosphorus loading is suggested from the results of these experiments. The internal nutrient status of algal populations (e.g. Cladophora) must be considered in predictions of the impact of phosphorus management strategies on aquatic systems.

Auer, M. T., R. P. Canale, H. C. Grundler, and Y. Matsuoka. 1982. Ecological Studies and Mathematical Modeling of Cladophora in Lake Huron: 1. Program Description and Field Monitoring of Growth Dynamics. J. Great Lakes Res. 8(1): 73-83.

A 3-year program was conducted to examine the ecology of Cladophora glomerata and to develop a mathematical model useful in evaluating various management strategies for the control of this nuisance alga. This manuscript provides a detailed description of the field program and study site in support of subsequent papers dealing with the results of field monitoring, autecological studies, calibration and verification of the model, and the impact of a demonstration phosphorus removal program of *Cladophora* growth. A municipal wastewater treatment plant discharge at Harbor Beach, Michigan, on Lake Huron has resulted in severe nuisance conditions associated with the presence of *Cladophora*. An intensive field monitoring program was established at the site to record weather conditions daily, and levels of dissolved and stored phosphorus and standing crop of *Cladophora* on a weekly basis. The distribution of *Cladophora* was shown to be essentially symmetrical about the nutrient source. Seasonal variation in biomass followed a pattern of early spring growth, stabilization, and midsummer senescence. The high degree of spatial and temporal heterogeneity in the nearshore environment was clearly evident from the results of the monitoring program. Wind direction and velocity importantly affect dissolved phosphorus distribution. Internal phosphorus levels reflect long term trends in wind and current regimes. The growth of *Cladophora* is importantly influenced by internal phosphorus levels while the loss of algal material through sloughing is closely correlated with wind-storm events. The observations of nearshore dynamics point to the need for high sampling frequency in such systems.

Bandiera, S., S. Safe, and A. B. Okey. 1982. Binding of Polychlorinated Biphenyls Classified as Either Phenobarbitone-, 3-Methylcholanthrene- or Mixed-Type Inducers to Cytosolic Ah Receptor. Chem.-Biol. Interact. 39: 259-277.

It has been postulated that reversible, high-affinity binding of 3-methyl-cholanthrene (MC)-type inducers to a receptor protein (the Ah receptor) in hepatic cytosol is essential for induction of aryl hydrocarbon hydroxylase (AHH) enzyme activity. To test this postulate, the binding affinities of 16 highly-purified, synthetic chlorinated biphenyl (PCB) congeners, which have been categorized either as phenobarbitone(PB)-, MC- or mixed (PB + MC)-type inducers of cytochrome P-450-dependent monooxygenases have been examined. The affinity of individual biphenyl congeners for the receptor was determined by their competition with 2,3,7,8-[^{3}H]tetrachlorodibenzo-p-dioxin ([^{3}H]TCDD) for specific cytosolic binding sites as measured by sucrose density gradient analysis following dextran-charcoal treatment.

This assay demonstrates (a) that the receptor binds with highest affinity to 3,3',4,4',5-pentachlorobiphenyl and 3,3',4,4'-tetrachloro-biphenyl ('pure MC-like' inducers); (b) mixed-type PCB inducers also bind to the receptor but with an affinity (average EC50-value of 8.6 μM) lower than that for 3,3',4,4',5-pentachlorobiphenyl; this corresponds with their relatively lower potencies as AHH inducers; (c) the receptor binds 2,2',4,4'-tetra-, 2,3,4,5-tetra-, 2,2',4,4',5,5'-hexa and 2,3',4,4',5',6-hexachlorobiphenyl at high concentrations (0.1 mM), whereas PB fails to bind, even at a concentration of 10 mM. All PCBs tested competed with [^{3}H] TCDD for Ah receptor, but there was a great variation in their relative binding affinities. The fact that two chlorinated biphenyls classed as 'PB-like' inducers and two chlorinated biphenyls which are neither 'PB- nor MC-type' inducers competed, coupled with the fact that PB did not bind to the receptor suggest that chemicals other than 'pure MC-type' inducers can bind to the cytosolic receptor. Affinity of the binding dictates the relative potency of given PCB congeners as inducers of cytochrome P-448.

Bartone, C. R., and C. L. Schelske. 1982. Lake-Wide Seasonal Changes in Limnological Conditions in Lake Michigan in 1976. J. Great Lakes Res. 8(3): 413-427.

Data collected on lake-wide cruises in 1976 were used to study seasonal and vertical variations in water temperature, transparency, chlorophyll a, and nutrients in Lake Michigan. Data were analyzed according to subsets corresponding to the northern and southern open lake. Comparisons (t-tests) of data from the open lake indicated that the average water temperature was cooler and average water transparency was greater in the northern lake than in the southern, but with the exception of total phosphorus, average nutrient concentrations did not differ between the northern and southern parts. It was found that physical-chemical characteristics of nearshore and Straits of Mackinac stations differed significantly from open lake stations. Seasonal phytoplankton dynamics in the open lake were related to seasonal and vertical changes in silica and nitrate nitrogen. The spring phytoplankton bloom occurred before the lake was strongly stratified thermally. After thermal stratification was well developed, epilimnetic concentrations of chlorophyll a decreased, probably due to some combination of nutrient limitation and zooplankton grazing, and maximum chlorophyll a concentrations were found below the thermocline. Epilimnetic silica concentrations decreased after thermal stratification and diatoms were replaced in the phytoplankton assemblage by green and blue-green algae in late summer. Total phosphorus averaged only 8 µg/l on a lake-wide basis and thus only small but significant reductions in absolute concentration can be expected from phosphorus control programs. However, over a period of several years, these small reductions in concentration may be difficult to verify from total phosphorus measurements which have relatively large sampling errors and variances.

Basak, S. C., D. P. Gieschen, V. R. Magnuson, and D. K. Harriss. 1982. Structure-Activity Relationships and Pharmacokinetics: A Comparative Study of Hydrophobicity, Van Der Waals' Volume and Topological Parameters. Int. Res. Commun. Series, Med. Sci. 10: 619-620.

While log P appears to be the sole determinant of log T, some theoretical studies indicate that there is a definite "steric basis of hydrophobicity" because the dominant source of energy for hydrophobic interactions of solute in water depends on molecular shape and size. Moreover, some recent studies, where log P is highly correlated with V_w and topological indices, provide further evidence for the geometrical/topological basis of hydrophobic behavior. This may be the reason for the excellent correlation of log T with V_w and other topological steric parameters. The dependence of lipophilicity of the barbiturates upon molecular shape and size is evident from the correlation of log P with IC (0.950), CIC (0.984), 1_X (0.873), 1_X^v (0.989), W (0.964), I_D^W (0.942), I_D^W (0.963) and V_w (0.855).

Bedford, K. W., R. E. Van Evra, III, and H. Valizadeh-Alavi. 1982. Ultrasonic Measurement of Sediment Resuspension. IN: Proceedings of the Conference Applying Research to Hydraulic Practice (P.E. Smith, ed.), pp. 575-583, American Society of Civil Engineers, New York, New York.

Recognizing the need for improved measurement and parameterization of sediment resuspension, this paper presents a review of the major methods now in use for alleviating this need. Special attention is devoted to reviewing methods for obtaining sediment concentration profiles by acoustic scattering methods and the microcomputer based C-DART Tower developed by the authors to simultaneously measure wave, current, and sediment profile data. The presence of spatial data requires a new approach to its analysis. A generalized pattern recognition program for geophysical flows is discussed.

Benoit, D. A., V. R. Mattson, and D. L. Olson. 1982. A Continuous-Flow Mini-Diluter System for Toxicity Testing. Water Res. 16: 457-464. ERL-D Reprint #262.

A space saving portable mini-diluter exposure system for testing early life stages of fish and invertebrates has been developed and successfully used both in the laboratory and on-site with single chemicals and with complex effluents. This gravity-operated system can also be installed in a compact, vented enclosure to permit safe testing of hazardous volatile chemicals. The mini-diluter test system has several additional advantages over other widely used dosing systems in that it: (1) uses small volumes of complex effluents and/or single chemicals which reduces the problem of removing hazardous material from the test system's waste water; (2) works well with waste containing suspended solids; and (3) can maintain normal operation for up to 10 h if the effluent headbox supply pump fails and up to 4 h if the diluent water headbox supply pump fails.

Benoit, D. A., F. A. Puglisi, and D. L. Olson. 1982. A Fathead Minnow Pimephales promelas Early Life Stage Toxicity Test Method Evaluation and Exposure to Four Organic Chemicals. Environ. Pollut. (Series A) 28: 189-197. ERL-D Reprint #278.

A 32-day test was developed at the Environmental Research Laboratory-Duluth for conducting early life stage (ELS) toxicity tests with fathead minnows Pimephales promelas. These test procedures were evaluated using the prescribed methods to establish estimated maximum acceptable toxicant concentrations (MATC) for fathead minnows exposed to four previously untested organic chemicals. Toxic effects on early developmental stages demonstrated that larval growth and survival were the most sensitive indicators of toxic stress. Embryo hatch and larval deformities at hatch were the least sensitive indicators of toxicity. The estimated MATCs for fathead minnows exposed to hexachlorobutadiene, 1,2-dichloropropane, 1,3-dichloropropane and 1,2-dichloroethane lie between 6.5 and 13 μg litre^{-1}, 6 and 11 mg litre^{-1}, 8 and 16 mg litre^{-1} and 29 and 59 mg litre^{-1}, respectively. Results obtained from the four ELS test method evaluations and the estimated MATCs derived from these evaluations demonstrate the consistency of the ELS toxicity test procedures for fathead minnows currently being adopted as standards by the U.S. Environmental Protection Agency and the American Society for Testing and Materials. These ELS test methods produced good replication and, when used to predict long-term chronic toxicity, will provide a rapid means to develop water quality criteria and screen large numbers of single chemicals or complex effluents.

Bergman, H. L., and J. S. Meyer. 1982. Complex Effluent Fate Modeling. IN: Modeling the Fate of Chemicals in the Aquatic Environment (K. L. Dickson et al., eds.), Chapter 14, pp. 247-267, Ann Arbor Science, Ann Arbor, Michigan.

Traditionally, the objective of single-compound fate models, whether they are mathematical (rate) or physical (microcosm) models, has been to predict environmental concentrations of pollutants. This should also be the ultimate objective of complex-effluent models, but these models must be somewhat different since we do not always know the identities of all compounds for which environmental concentrations must be estimated. Thus, we suggest that the objectives of a complex-effluent modeling strategy should be: 1) to identify constituents posing an environmental fate problem; and 2) to predict expected exposure concentrations (EEC) of each constituent posing a problem.

In this chapter we illustrate the modeling problem posed by complex-effluents, reviewing mathematical and physical modeling strategies currently being developed for complex effluents, and discussing the trade-offs between mathematical and physical models for complex-effluent mixtures.

Bierman, V. J., Jr., and W. R. Swain. 1982. Mass Balance Modeling of DDT Dynamics in Lakes Michigan and Superior. Environ. Sci. Technol. 16: 572-579.

A retrospective analysis of DDT dynamics subsequent to the imposition of a ban on DDT use in 1969 was conducted for Lakes Michigan and Superior. Trends in the available data indicate that DDT levels in both lakes declined at greater rates than were expected on the basis of hydraulic detention times and the degradation rate for DDT in the environment. Under the given assumptions, settling of particulate DDT from the water column was found to be the major loss process of DDT for both lakes. Particulate settling was responsible for 61-95% of the observed DDT loss rate in Lake Michigan. Degradation and hydraulic washout were responsible for 3-35% and 2-4%, respectively. Results for Lake Superior were comparable. These ranges corresponded to results for sensitivity analyses to variations in external DDT loads, partition coefficients, and degradation half-times. Results for apparent net particulate settling velocities for DDT were consistent with analogous results for phosphorus, phytoplankton, and plutonium from independent studies.

Biesinger, K. E., L. E. Anderson, and J. G. Eaton. 1982. Chronic Effects of Inorganic and Organic Mercury on Daphnia magna: Toxicity, Accumulation, and Loss. Arch. Environ. Contam. Toxicol. 11: 769-774. ERL-D Reprint #288.

The chronic toxicity of mercury (Hg) to Daphnia magna was studied under flow-through and renewed-static conditions. Concentrations of mercuric chloride ($HgCl_2$), methyl mercuric chloride (MMC) and phenyl mercuric acetate (PMA) in flow-through tests significantly affecting survival were 1.92, between 0.26 and 0.98, and 2.25 µg Hg/l, respectively. Concentrations of $HgCl_2$, MMC, and PMA significantly impairing young production ($P \leq 0.05$) were 0.72, 0.04, and 1.90 µg Hg/l, respectively. Body accumulation of mercury was greatly influenced by the chemical form of mercury in water. About nine times more mercury, added as MMC, was tolerated in daphnids at water concentrations permitting survival than was tolerated when added as $HgCl_2$. At about the same mercury concentration in water (~0.26 µg Hg/l) daphnids accumulated ~20 times more mercury when it was added as MMC than when it was added as $HgCl_2$. Mercury was rapidly accumulated in daphnids; however, 35 and 57% of the mercury added as MMC and $HgCl_2$, respectively, was lost when animals were placed in control water for four days following exposure. Different forms of mercury behaved quite differently in renewed-static and flow-through systems. The results also indicate the shortcomings of renewed-static tests with volatile and readily degradable compounds.

Canale, R. P., and M.T. Auer. 1982. Ecological Studies and Mathematical Modeling of Cladophora in Lake Huron: 5. Model Development and Calibration. J. Great Lakes Res. 8(1): 112-125.

The development of a mathematical model for calculating the spatial distribution and temporal variation in Cladophora biomass and selected forms of phosphorus at a site on Lake Huron is described. The model is intended for use in evaluating the utility of various phosphorus management strategies in reducing the nuisance growth of Cladophora in the Great Lakes. The model is composed of a transport component which accounts for bulk transfer and exchange of phosphorus within the system and a kinetic component which describes chemical and biological reactions. The kinetic component includes the effects of light, temperature, and internal phosphorus levels on Cladophora growth rate, aspects of phosphorus uptake, and the impact of sloughing and self-shading on standing crop. The numerical value of coefficients associated with kinetic equations have been independently determined through laboratory studies. The model has been calibrated to a data set collected in the vicinity of the Harbor Beach, Michigan, wastewater treament plant. A satisfactory fit was achieved for model calculations and observed levels of *Cladophora* biomass, internal phosphorus, and soluble reactive phosphorus. The model has few degrees of freedom because the coefficient values were fixed from field and laboratory measurements. A standing crop of *Cladophora* biomass of 300 gDW/m^2 with an internal phosphorus level of 0.35%P was characteristic of stations in the vicinity of the nutrient source. Soluble reactive phosphorus levels fluctuated widely due to mixing of the effluent plume with offshore waters, but averaged approximately 30 μgP/l. A distinct spatial trend was observed with *Cladophora* biomass, internal phosphorus, and soluble reactive phosphorus decreasing with distance from the point source of nutrients. The opportunity for model verification by perturbation through phosphorus removal is discussed.

Canale, R. P., M. T. Auer, and J. M. Graham. 1982. Ecological Studies and Mathematical Modeling of *Cladophora* in Lake Huron: 6. Seasonal and Spatial Variation in Growth Kinetics. J. Great Lakes Res. 8(1): 126-133.

The routine output of a mathematical model for *Cladophora* growth provides a useful integration of the biological, chemical and physical factors involved, but affords little information regarding the individual importance of key mechanisms. This manuscript describes model calculations of the seasonal and spatial variation in the processes regulating the growth of *Cladophora*. The impact of light, temperature, internal phosphorus levels, and self-shading are described on a seasonal basis. Details of phosphorus dynamics and the importance of self-shading are examined spatially. It is concluded that light and temperature are the primary variables regulating the seasonal growth dynamics of *Cladophora*. In cases where the presence of *Cladophora* is associated with a point source of nutrients, the growth rate is directly related to distance from the nutrient source. Seasonal cycles of *Cladophora* growth and the distribution of the alga with respect to depth are examined in terms of a critical energy balance between light-enhanced respiration and gross photosynthesis.

Canale, R. P., and M. T. Auer. 1982. Ecological Studies and Mathematical Modeling of *Cladophora* in Lake Huron: 7. Model Verification and System Response. J. Great Lakes Res. 8(1): 134-143.

This manuscript describes the verification of a calibrated mathematical model designed to predict the spatial and temporal distribution of *Cladophora* about a point source of nutrients. The study site was located at Harbor Beach, Michigan, on Lake Huron. The model is intended to have a widespread utility for evaluating the impact of phosphorus removal on the nuisance growth of Cladophora. Therefore, verification was attempted by implementing phosphorus removal at the study site.

Phosphorus removal efficiencies at the Harbor Beach, Michigan, wastewater treatment plant averaged 80-90% following the implementation of alum precipitation. The average loading of soluble reactive phosphorus was reduced from 1.35 kg P/day in 1979 to 0.20 kg P/day in 1980. The standing crop, areal distribution, and duration of abundance of Cladophora biomass were considerably reduced in 1980. Lower ambient levels of soluble reactive phosphorus resulted in a reduction of internal phosphorus from about 0.34% P in 1979 to 0.14% P in 1980 for sites in the vicinity of the nutrient source. The growth rate of Cladophora is directly related to internal phosphorus levels in phosphorus limited environment. Productivity calculations indicate an 80% reduction in standing crop and gross productivity and a 90% reduction in sloughed biomass. Beach accumulation of sloughed algae was sharply reduced in 1980. Model predictions of the response of Cladophora populations to reductions in phosphorus loading agreed well with field observations. It is concluded that the verified model is suitable for examination of the impact of various phosphorus management strategies on the growth of Cladophora.

Canale, R. P., Y. Matsuoka, T. M. Heidtke, M. T. Auer, and S. J. Wright. 1982. Management of Nuisance Growth of Cladophora. IN: Proceedings of the ASCE Environmental Engineering Division Specialty Conference, pp. 393-401, Minneapolis, Minnesota.

Nuisance conditions associated with Cladophora growth may be ameliorated by reducing the concentration of phosphorus in the waters supporting growth. In areas where algal production is influenced by local point sources of phosphorus, two alternative control strategies are often considered. One procedure involves discharging effluents to offshore areas, distant from the physical environment suitable for Cladophora growth. This approach, commonly practiced in Canada, relies on dilution and dispersion to reduce lakewater concentrations of phosphorus. Another approach, often employed in the United States, emphasizes chemical treatment for phosphorus removal and direct discharge of the effluent to the nearshore zone. Although either procedure may be employed to reduce phosphorus concentrations, control of Cladophora populations to aesthetically acceptable levels may be extremely costly. The high cost of control programs tends to discourage efforts to reduce this significant nuisance problem in the Great Lakes.

It is appropriate, therefore, to explore approaches which minimize the cost associated with the control of Cladophora. This paper examines alternative strategies for reducing Cladophora growth which involve combinations of phosphorus removal and offshore discharge. Solutions are sought which control nuisance growth at minimum cost. The link between alternative abatement strategies and acceptable levels of

Cladophora biomass is provided by a mathematical model calibrated at a site on Lake Huron. This paper describes the development of the model and its application for determining optimal cost control strategies for nuisance conditions of *Cladophora* growth.

Canton, S. P. 1982. Comparative Limnology and Biota of Mine Spoils Ponds in Colorado. Southwest. Nat. 27(1): 33-42.

Physico-chemical and biotic parameters were investigated from June 1977 to May 1978 in coal strip-mine ponds in Colorado which differed in age and in the proportion of drainage derived from the mine. There were no discernible effects of mine drainage on temperature, dissolved oxygen, hardness, pH, acidity, alkalinity, calcium, iron, orthophosphate, or the organic content of the substrate. In contrast to spoils ponds in eastern and midwestern states, acid mine drainage was not observed. Total dissolved solids, nitrate, and sulfate values were higher in the spoils ponds than in the control pond. Net zooplankton abundance was lowest in the youngest spoils pond, but the standing crop of benthos exhibited a progressive decrease from the youngest spoils pond to the control pond. Certain zooplanktonic and benthic species were rare or absent in the youngest spoils pond. Colonization phenomena (age and distance from a source of colonizers) are postulated as responsible, in part, for the faunal differences between ponds, although higher levels of nitrate, sulfate, and TDS in the spoils ponds may provide adverse conditions for certain species. If these data are typical of the western energy region, they suggest the potential for development of recreational lakes as a part of reclamation practices.

Carlson, R. W. 1982. Some Characteristics of Ventilation and Coughing in the Bluegill *Lepomis macrochirus* Rafinesque. Environ. Pollut. (Series A) 29: 35-56. ERL-D Reprint #279.

Simultaneous measurement of buccal water-pressure changes verified the presence of coughing maneuvers on strip-chart recordings of bioelectric potentials associated with respiratory movements and sensed with non-contact electrodes from cannulated bluegills. Additional recordings, here called 'electrobranchiograms' (EBGs), showed that non-cannulated and well-acclimated bluegills normally display an arrhythmic respiratory pattern similar to Biot's breathing, in which pauses in breathing (apnea) characteristically alternate with groups of ventilating cycles. Three types of bluegill coughing maneuvers were identified: type I, the most common form, were large amplitude coughs due to an interruption and momentary reversal of developing bioelectric potential of a ventilating cycle followed by a substantial burst in potential; type II, a quick spike-like cough, occurred as a momentary pause in potential followed by a burst and type III coughs were an interruption and reversal, usually near the peak of a ventilating cycle and without the accompanying burst in potential. The cough occupied from about one-seventh to one-fifth of a normal ventilating cycle as seen on an EBG and occurred 1.2±0.6 times a minute in well-rested fish. Enhanced amplitude relative to adjacent ventilatory cycle (≈1.5 times) was the most important factor in determining when acclimated bluegills coughed, but coughing amplitude often diminished during exposure to zinc sulphate even though the depth of ventilation appeared to increase substantially.

Chopra, K. S., D. Beaman, and P. Cook. 1982. Interlaboratory Measurements of the Chrysotile Asbestos Fiber and Mass Concentrations in Water Samples. IN: National Bureau of Standards Special Publication 619. Proceedings of the NBS/EPA Asbestos Standards Workshop held at NBS, Gaithersburg, Maryland, Oct. 1-3, 1980. ERL-D Reprint #293.

In interlaboratory determinations of the chrysotile asbestos concentrations in water, it was found that: 1) The accuracy in the determination of mass in μg/l is about 50 percent, and is systematically low, i.e., the average recovery is 50 percent. 2) The precision in the determination of mass and fiber concentration is about ±50 percent. 3) The precision of the analyses did not improve during the three years of analyses involving six different chrysotile-containing samples. 4) Water samples retained in glass tend to produce lower mass determinations as the length of storage is increased. 5) Selected area electron diffraction provides highly variable results. In samples where the only fibers were chrysotile, the portion of fibers reported as to giving positive SAED patterns varied from 0-97 percent. The average fraction of chrysotile fibers with positive SAED for all investigators and investigations was 47 percent.

Christensen, G. M., D. Olson, and B. Riedel. 1982. Chemical Effects on the Activity of Eight Enzymes: A Review and a Discussion Relevant to Environmental Monitoring. Environ. Res. 29: 247-255. ERL-D Reprint #290.

The effects of selected water pollutants and other chemicals on the activity of eight enzymes (in vitro) are summarized. The information may give insight into the mechanism of action of toxic chemicals and have application in the development of a rapid screening procedure involving enzymes as biomonitors in analyzing water quality.

Coffin, D. L., L. D. Palekar, and P. M. Cook. 1982. Tumorigenesis by a Ferroactinolite Mineral. Toxicol. Lett. 13: 143-150. ERL-D Reprint #282.

In lifetime exposure of male Fischer-344 rats to ferroactinolite fibers and to UICC amosite asbestos fibers by means of intratracheal and intrapleural treatments, oncogenesis was greater in the lung for the ferroactinolite and in the pleura for the amosite. The lack of correlation between the effects of the two methods of exposure suggests that in this instance, intrapleural inoculation was not a good predictor of pulmonary response on the basis of mass dose. Another feature of the ferroactinolite was that pleural tumors resulted from intratracheal instillations. Conversely, lung tumors or tumorlike lesions were also induced by intrapleural inoculations of ferroactinolite. These facts suggest a greater in vivo transport for the ferroactinolite than for the amosite.

Since there are far fewer mineral fibers per mass unit in the ferroactinolite the tumor yield per unit of mineral fibers was strikingly greater by both routes of administration for ferroactinolite than for amosite.

Coleman, R. A., R. D. Edstrom, M. A. Unger, and R. J. Huggett. 1982. Field Technique for Monitoring p-Cresol in Streams. Anal. Chem. 54: 2631-2632.

A flow-through instrument design is described which allows reliable determinations of phenols in water to be made. Concentration measurements in the low mg/l range and analysis times of 30-60 sec. are readily achieved. Data obtained from a continuous 96-h dose on experimental fresh-water streams showed excellent agreement (1-2% difference) with gas chromatographic determinations.

Connolly, J. P., and R. V. Thomann. 1982. Calculated Contribution of Surface Microlayer PCB to Contamination of Lake Michigan Lake Trout. J. Great Lakes Res. 8(2): 367-375.

The possible significance of PCB concentration in the surface microlayer of Lake Michigan to contamination of lake trout was examined using a modification of a previously developed food chain model. Vertically migrating zooplankton were assumed to spend a fraction of each day exposed to a surface microlayer with dissolved and phytoplankton PCB concentrations at values that resulted in an average exposure concentration 2.1 times greater than subsurface levels. Considering a worst case scenario, the model indicated that approximately 12% (3 μg/g) of the PCB concentration in adult lake trout could be contributed from the microlayer.

Cook, P. M., and D. R. Marklund. 1982. Sample Preparation for Quantitative Electron Microscope Analysis of Asbestos Fiber Concentrations in Air. pp. 53-67. IN: National Bureau of Standards Special Publication 619, Proceeding of the NBS/EPA Asbestos Standards Workshop, Gaithersburg, Maryland, pp. 53-67, Oct. 1-3, 1980. ERL-D Reprint #267.

The ability to determine asbestos fiber concentrations and size distributions depends on the electron microscope observation of the particles in very small fields of view that constitute microcosms representative of the total sample. Sample preparation procedures are a critical consideration in the quest for acceptable accuracy and precision because they have a direct influence on the number and size of particles observed. Loss of particles, physical or chemical degradation, particle contamination, alteration of particle size distribution are problems associated with sample preparation procedures. Basic methods for collecting particles suspended in air or water on membrane filters and then transferring them to electron microscope grids will be discussed with respect to these problems. Preparations of biological samples (tissues, food, fluids) and standard samples from dry powders are complicated by the need to manipulate the sample to obtain particle suspensions in water suitable for filtration on a membrane filter. The desirable effects of the use of ashing, chemical digestion, surfactants, sonification, centrifugation, and agitation techniques must be weighed against the possibilities for sample alteration associated with each manipulation of the sample. Results from interlaboratory comparison studies have indicated that different sample preparation procedures frequently result in poor agreement between the laboratories using the procedures.

Cook, P. M., L. D. Palekar, and D. L. Coffin. 1982. Interpretation of the Carcinogenicity of Amosite Asbestos and Ferroactinolite on the Basis of Retained Fiber Dose and Characteristics In Vivo. Toxicol. Lett. 13: 151-158. ERL-D Reprint #281.

Rats were exposed to amosite asbestos and ferroactinolite fibers by intrapleural inoculation and intratracheal instillation. The ferroactinolite sample was found to be more carcinogenic in both exposures than the amosite sample on the basis of total fiber dose or fiber dose expressed for any size category of hypothetical greatest carcinogenic potency. Quantitative transmission electron microscope analysis of low-temperature ashed whole lung samples collected at different times following intratracheal instillation of fibers demonstrated that concentrations and sizes of fibers retained in rat lungs were greatly influenced by the relative ability of each mineral to undergo longitudinal splitting as a consequence of dissolution in vivo. Ferroactinolite fibers rapidly split to produce many thin fibers so that the number of ferroactinolite fibers retained in the lung 2 years after intratracheal instillation was four times greater than the number of fibers originally instilled. The number of short, thin ferroactinolite fibers retained (10-fold more than amosite) after in vivo splitting best explains the greater lung carcinogenicity of ferroactinolite compared to amosite.

Dalich, G. M., R. E. Larson, and W. H. Gingerich. 1982. Acute and Chronic Toxicity Studies with Monochlorobenzene in Rainbow Trout. Aquat. Toxicol. 2: 127-142.

The toxicity of monochlorobenzene (CB) was investigated in rainbow trout following acute intraperitoneal (i.p.) administration and chronic exposure via the water in a continuously flowing system for 15 or 30 days.

In the acute study overt toxicity and hepatotoxicity was monitored over a 96-h time period. Variables measured to assess toxicity included weight changes, liver weight to body weight ratios, behavioral changes, alanine aminotransferase activity (GPT), sulfobromophthalein (BSP) retention, total plasma protein concentration and liver histopathology. In the chronic study the same measures of toxicity were followed as well as food consumption and alkaline phosphatase (AP) activity.

Upon acute i.p. exposure the toxicant (9.8 mmol/kg) caused behavioral changes in the fish which were consistent with the known anesthetic properties of CB in mammals. Elevations in BSP retention and GPT activity, and histopathology indicated that CB was hepatotoxic in fish.

The LC50 of CB in trout exposed via the water for 96 h was 4.7 mg/l. Chronic exposure of trout to 2 or 3 mg/l CB resulted in similar behavioral changes as seen in the acute study. Liver toxicity was evident from elevations in GPT activity. BSP retention and AP activity appeared to be affected by the nutritional status of the trout as much as by the CB treatment. After 30 days of exposure to 3 mg/l CB, trout appeared to have developed some tolerance to the toxic effects.

DePinto, J. V. 1982. An Experimental Apparatus for Evaluating Kinetics of Available Phosphorus Release from Aquatic Particulates. Water Res. 16: 1065-1070.

An experimental apparatus, referred to herein as a Dual Culture Diffusion Apparatus (DCDA), has been developed and operated to permit the extraction of process kinetic data for several types of particle-water interactions. The DCDA is constructed of two culture vessels separated only by a thin membrane filter, thus facilitating the separation of two particulate suspensions while at the same time permitting their interaction by diffusion of dissolved substances through the membrane. This manuscript describes how the apparatus has been calibrated and applied to measure the rate at which available phosphorus is released from various types of particulates suspended in lake water media.

DiToro, D. M., L. M. Horzempa, M. M. Casey, and W. Richardson. 1982. Reversible and Resistant Components of PCB Adsorption-Desorption: Absorbent Concentration Effects. J. Great Lakes Res. 8(2): 336-349.

Laboratory experiments and analysis of field data from Saginaw Bay show that the concentration of suspended adsorbent affects the partition coefficient of PCB. The coefficient consistently decreases as adsorbent concentration increases. In addition it has been found that adsorption and desorption are not completely reversible. An analysis of this effect is presented within the framework of the resistant-reversible component model of adsorption-desorption. The partition coefficients for these two components are found to behave quite regularly: the resistant component exhibits essentially constant partitioning whereas the reversible component partition coefficient is exactly inverse to adsorbent concentration. The interplay of these components determines the variation of the adsorption and desorption partition coefficients as functions of adsorbent concentration and the degree of reversibility to be expected. Saginaw Bay field data conform to the relationship derived from the resistant-reversible model.

Eisenreich, S. J. 1982. Atmospheric Role in Trace Metal Exchange at the Air-Water Interface. J. Great Lakes Res. 8(2): 243-256.

Trace metals are enriched in the surface film (SF) in freshwater and marine environments as compared to the bulk water. Contributions to the metal burden of the SF are derived both from atmospheric fallout and in-lake bubble-scavenging processes. A significant fraction of the Cu, Cd, Pb, and Zn in southern Lake Michigan SFs is derived from aerosol deposition. Geochemical analysis of aerosol, SF, and bulk water of Lake Superior strongly suggest that 1) most of the Fe, Mn, Ca, Pb, Cr, Zn, Cd, and Ni in the SF is derived from in-lake processes; and 2) enrichment of Cu, Pb, Zn, and Cd in lake aerosol is partially a result of bubble-bursting at the air-water interface. Estimated metal residence times in the SF may be on the order of minutes. Although the total quantity of metal in the SF represents a negligible fraction of the total water burden, the metal accumulation and enrichment at the air-water interface without geochemical/physical controls (i.e., precipitation, sedimentation) in a biologically-active regime suggests its importance in biotic uptake and possible direct introduction into the food chain.

Eisenreich, S. J. 1982. Overview of Atmospheric Inputs and Losses from Films. J. Great Lakes Res. 8(2): 241-242.

The air-water interface in natural aquatic systems is often characterized by a surface film consisting of a thin layer of surface-active organic matter incorporating inorganic and organic dissolved and particulate matter. The surface film of both marine and freshwater systems concentrates nutrients, metals, and organic matter (natural and anthropogenic) above that found in the bulk surface water. Oftentimes, the particulate matter is enriched in metal and organic content above that found for particulate matter in the bulk water, but often similar to the atmospheric aerosol. The placement of the surface film at the air-water interface indicates that its composition is a result of in-lake scavenging processes and wet plus dry atmospheric deposition. The sources for and residence times of various contaminants in the surface film are discussed.

Fisher, J. B., G. Matisoff, and W. J. Lick. 1982. Downcore Variation in Sediment Organic Nitrogen. Nature 296(5855): 345-345.

An historical record of natural (pre-cultural) and anthropogenic (influenced by man's activities) chemical inputs to the environment is contained in accumulating sediment deposits and is commonly expressed as a depositional flux. This flux is traditionally calculated as the product of the sediment accumulation rate and the concentration of a substance in the sediment. Previous work has quantified depositional fluxes of metals and nutrients by assuming that the vertical distribution of these substances in sediments is unaffected by post-depositional migration, chemical reaction or porosity variations. We present here a procedure for calculating the historical depositional flux (loading record) of a substance which undergoes post-depositional chemical reaction in a compacting sediment column. The method is demonstrated by calculating the loading record of organic nitrogen at one locality in Lake Erie.

GKY and Associates, Inc. 1982. Tidewater Potomac Cleanup "A Decade of Progress". Problem-Oriented Report, Contract #EPA/68023172, A Report for The Environmental Protection Agency, Work Assignment I, Published by Interstate Commission on the Potomac River Basin, April 1982, 58 pp.

The primary objective of this report is to show the impact of the current pollution control program on the water quality conditions of the tidewater Potomac.

Numerous studies, technical reports and articles have addressed the problem of pollution in the tidewater Potomac. Most of these efforts have taken a short-term view of the effects of pollution. This report documents the changes in pollution inputs and the resulting water quality effects that have occurred in the tidewater over a ten-year period.

This study of water quality trends is a comparative analysis of an early period, 1969-1970, which reflects conditons before advanced sewage treatment began, and a later period, 1977-1979 which reflects the effectiveness of a program that stresses phosphorus removal.

Glass, G. E., and T. G. Brydges. 1982. Problem Complexity in Predicting Impacts from Altered Precipitation Chemistry. IN: Proc. Intern. Symp. on Acid Precipitation and Fishery Impacts in Northeastern North America, Cornell Univ., Ithaca, New York.

> Assessment of pollutant effects on living organisms is difficult because of the lack of quantitative dose-response relationships, especially in regional situations where large temporal and spatial variations of pollutants may occur. In the U.S./Canada Aquatic Impacts Assessment, part of the Memorandum of Intent on Transboundary Air Pollution, dose-response relationships had to be addressed for regional systems-whole lakes and watersheds where multiple pollutants are involved over a wide variation of resource susceptibility. Data from the literature, field studies, and descriptive models provide an important part of the available information base. This information is used to examine atmospheric pollutant loadings and impacts to aquatic systems in North America and to estimate reduced levels of acidic deposition necessary to protect and restore water quality and sensitive biota.

Gotham, I. J., and G.-Y. Rhee. 1982. Effects of a Hexachlorobiphenyl and Pentachlorophenol on Growth and Photosynthesis of Phytoplankton. J. Great Lakes Res. 8(2): 328-335.

> The effects of two organochlorine compounds 2,4,5,2',4',5'-hexachlorobiphenyl (HCB) and pentachlorophenol (PCP) on photosynthesis and growth were investigated in semicontinuous cultures of three species of algae: *Ankistrodesmus falcatus*, *Melosira* sp., and *Microcystis* sp. Photosynthesis appeared to be stimulated by HCB in *A. falcatus* and *Melosira* sp., both per cell and per unit of chlorophyll, at average cellular HCB concentrations of approximately 3×10^{-5} and 6×10^{-6} ng $cell^{-1}$ respectively. At the same HCB concentrations the growth rate of *Melosira* was significantly inhibited, but that of *A. falcatus* showed no significant trend. PCP appeared to inhibit photosynthesis in *A. falcatus* and *Microcystis* sp., both per cell and per unit of chlorophyll, at a cell PCP concentration range of approximately $4\text{-}8 \times 10^{-7}$ and $2\text{-}11 \times 10^{-8}$ ng $cell^{-1}$, respectively. In *Melosira*, photosynthesis per unit of chlorophyll was inhibited at $2\text{-}6 \times 10^{-7}$ ng $cell^{-1}$. At these PCP concentrations, only *Melosira* showed a discernible decrease in growth rate.

Gotham, I. J., and G.-Y. Rhee. 1982. Effects of Nitrate and Phosphate Limitation on Cyclostat Growth of Two Freshwater Diatoms. J. Gen. Microbiol. 128: 199-205.

> The effects of N and P limitation on cell division and on cellular contents of limiting and non-limiting nutrients were examined in cyclostat cultures of the freshwater diatoms *Asterionella formosa* and *Fragilaria crotonensis*. Nutrient-limited cell cycles of both species

were readily entrained by a 14 h/10 h light/dark cycle. In F. crotonensis, the maxima relative to the onset of the light phase of the photocycle occurred at approximately -1 to +1 h for cell division, ±11 to 13 h for cell N, and +21 to 23 h for cell P. In A. formosa the maxima occurred at approximately +3 to 10 h for cell division and +2 to 4 h for cell N and cell P. Changes in culture dilution rate (integrated growth) and in the type of nutrient limiting growth did not significantly alter these times for either species. The cell-number oscillations can be explained by a simple exponential function for the instantaneous population growth rate, which occurs after a single modal transition time , which is characteristic for each species. The consistency of phase relations between N and P limitations and culture dilution rates suggests that the temporal organization for events within the cell cycle of each organism is independent of the nutrient-limited status of the cell populations.

Graham, J. M., M. T. Auer, R. P. Canale, and J. P. Hoffman. 1982. Ecological Studies and Mathematical Modeling of Cladophora in Lake Huron: 4. Photosynthesis and Respiration as Functions of Light and Temperature. J. Great Lakes Res. 8(1): 100-111.

Laboratory experiments were conducted with Cladophora glomerata isolated from Lake Huron near Harbor Beach, Michigan, to determine gross and net photosynthesis and respiration as functions of temperature and light intensity. Rates of net photosynthesis and respiration were measured in three replicate cultures at all combinations of eight temperatures (1° to 35°C) and eight light levels (12 to 1235 $\mu E/m^2 \cdot sec$) using oxygen electrode techniques. Maximum net photosynthesis occurred between 13 and 17°C and 300 to 600 $\mu E/m^2 \cdot sec$. The data were converted to specific rates of growth and respiration for use in a mathematical model, and three-dimensional response surfaces were generated for gross and net growth and respiration over the entire range of light levels and temperatures examined.

Hall, R. J., J. M. Pratt, and G. E. Likens. 1982. Effects of Experimental Acidification in Macroinvertebrate Drift Diversity in a Mountain Stream. Water, Air, Soil Pollut. 17: 2-15.

A small stream (Norris Brook) within the Hubbard Brook Experimental Forest was acidified to determine what effect elevated H^+ stress may have on the ecology of a mountain stream. The experiment was designed to simulate a pH level (4.0) that can occur during initial snowmelt (acute period) and during longer term (chronic period) acidification. Daily macroinvertebrate drift samples were collected from treatment and reference areas of Norris Brook. Drift diversity at the generic level was calculated using Brillouin's formula and partitioned hierarchically following macroinvertebrate classifications based on taxonomy (orders) and feeding strategies (functional groups or guilds). The rate of movement of individuals and genera was significantly greater for those organisms leaving the acid-stressed area during the first five days than for those entering, whereas no difference between the rate of macroinvertebrates entering or leaving the acid-stressed area was apparent for either numbers or genera over the remaining 25-day period. For the acute period (first five days), the increased macroinvertebrate drift leaving the acidified area was significantly more diverse at the levels of aquatic insect orders and functional groups but less diverse at the generic level than the drift entering. For the chronic period (25-day period) no significant differences were detected in either major taxa, functional group, (with the exception of collectors) or generic diversity between the drift entering and leaving the treatment reach. Mayflies and probably chironomids leaving the acid-stressed area during the acute period were generically more diverse than those entering, whereas stoneflies drifting out of the acidified reach were generically less diverse than those drifting in. The overall change in the normal pattern of spatial and temporal variation in drift rate and diversity provides quantitative evidence that H^+ stress significantly altered the structure and function of the macrobenthic community.

Hedtke, S. F., and F. A. Puglisi. 1982. Short-Term Toxicity of Five Oils to Four Freshwater Species. Arch. Environ. Contam. Toxicol. 11: 425-430. ERL-D Reprint #271.

Short-term lethality tests were conducted with five oils (waste oil, No. 1 fuel oil, No. 2 fuel oil, mixed blend sweet crude oil, Lloydminister crude oil) and four freshwater species. The oils were tested as floating layers, emulsions, and as the water-soluble fraction of 10% oil-water mixtures, in static and flow-through tests. The organisms tested were the American flagfish, _Jordanella floridae_, the fathead minnow, _Pimephales promelas_, larvae of the wood frog, _Rana sylvatica_, and larvae of the spotted salamander, _Ambystoma maculatum_. LC50 values were quite variable depending on a number of influencing factors, including the species tested, the type of oil, differences between batches of the same oil, the form of the oil when added to the test system, the type of test, duration of exposure, and the oil-water contact time.

Herdendorf, C. E. 1982. Environmental Improvements in Lake Erie During the Past Decade. Oceans (September): 1182-1185.

An analysis of Lake Erie water quality data for the past 10 years indicates a general improvement in the lake environment. Concentrations of phosphorus were relatively constant during the period 1970 to 1977; however, since that time significant declines have been observed. This improvement coincides with the approximate 800-metric-ton-per-year reduction in the phosphorus loading to the lake during the later part of the decade.

Holcombe, G. W., G. L. Phipps, and J. T. Fiandt. 1982. Effects of Phenol, 2,4-Dimethylphenol, 2,4-Dichlorophenol, and Pentachlorophenol on Embryo, Larval, and Early-Juvenile Fathead Minnows (*Pimephales promelas*). Arch. Environ. Contam. Toxicol. 11: 73-78. ERL-D Reprint #263.

> Embryos of fathead minnows were more resistant to phenol, 2,4-dimethylphenol (2,4-DMP), 2,4-dichlorophenol (2,4-DCP), and pentachlorophenol (PCP) than were larval or juvenile life stages. Growth of 28-day-old fish was the most sensitive indicator of stress during exposures to phenol, 2,4-DMP, and PCP, whereas survival was the most sensitive indicator of toxic effects from 2,4-DCP exposure. Based on these effects, the estimated maximum acceptable toxicant concentration for fathead minnows in Lake Superior water lies between 1,830 and 3,570 μg/l for phenol; 1,970 and 3,110 μg/l for 2,4-DMP; 290 and 460 μg/l for 2,4-DCP; and 44.9 and 73.0 μg/l for PCP.

Holcombe, G. W., G. L. Phipps, and D. K. Tanner. 1982. The Acute Toxicity of Kelthane, Dursban, Disulfoton, Pydrin, and Permethrin to Fathead Minnows *Pimephales promelas* and Rainbow Trout *Salmo gairdneri*. Environ. Pollut. (Series A) 29: 167-178. ERL-D Reprint #284.

> Flow-through acute lethal toxicity tests were conducted with kelthane, dursban, disulfoton, pydrin and permethrin using rainbow trout *Salmo gairdneri* and fathead minnows *Pimephales promelas* in Lake Superior water. Pydrin was the most toxic pesticide tested to both species of fish and was followed in order of decreasing toxicity by permethrin, dursban, kelthane and disulfoton. Rainbow trout were more sensitive than fathead minnows to all five pesticides. The 96-h LC50 values (μg litre^{-1}) for rainbow trout and fathead minnows, respectively, were: pydrin, 2.1 and 5.4; permethrin, 7.0 and 15.6; dursban, 8.0 and 203.0; kelthane, 210.0 and 510.0 and disulfoton, 3020.0 and 4000.0.

Jarvinen, A. W., and D. K. Tanner. 1982. Toxicity of Selected Controlled Release and Corresponding Unformulated Technical Grade Pesticides to the Fathead Minnow *Pimephales promelas*. Environ. Pollut. (Series A) 27: 179-195. ERL-D Reprint #265.

> Fathead minnows were exposed to three encapsulated slow-release pesticide formulations and three corresponding technical grade products used in their manufacture. Static 4-day LC50 values derived from aged stock solutions indicate increased toxicity with time for encapsulated methyl parathion, diazinon and their technical grades. The technical grades, however, were more toxic than the encapsulated. Encapsulated Dursban was less toxic with time, whereas toxicity remained similar with time for the technical grade. Flow-through 4-day LC50 values for methyl parathion, Penncap-M, Dursban, Dursban 10 CR and diazinon are 5.36, 6.91, 0.14, 0.12 and 6.9 mg litre^{-1}, respectively.

In general, long-term toxicity was similar for both pesticide forms. Growth (weight) was the most sensitive parameter measured in the 32-day embryo-larval tests, except for the Dursban 10 CR study where it was equally as sensitive as survival. Growth effects occurred at >0.31-<0.38, >0.38-<0.59, >0.0016-<0.0032, >0.0022-<0.0048, >0.050-<0.090 and >0.040-<0.076 mg $litre^{-1}$ for methyl parathion, Penncap-M, Dursban, Dursban 10 CR, diazinon and Knox Out 2 FM, respectively.

Water solubilities were slightly lower for the encapsulated compounds. Estimated half-lives were 18 days for methyl parathion and 15 days for Penncap-M; 41 days for Dursban and >200 days for Dursban 10 CR and approximately 30 days for diazinon and >230 days for Knox Out 2 FM.

Jensen, A. L. 1982. Impact of a Once-Through Cooling System on the Yellow Perch Stock in the Western Basin of Lake Erie. Ecol. Model. 15: 127-144.

The surplus production model, a conventional fishery stock assessment model, is applied to assess the entrainment and impingement impact of the Monroe Power Plant on the yellow perch standing stock and fishery in the western basin in Lake Erie. Biological parameters of the model are estimated from commercial catch and effort data and entrainment and impingement coefficients are estimated from power plant data. The model is applied to estimate stock biomass, egg production, and larva production; the proportions entrained and impinged are then estimated. The impact of water withdrawal on the equilibrium standing stock and maximum sustainable yield from the fishery is estimated and the impact of increased water withdrawal is simulated. The impact on equilibrium standing stock and the maximum sustainable yield are larger than the proportion of the standing stock entrained and impinged, but the impact of the Monroe Power Plant is relatively small; it decreases biomass and the maximum sustainable yield of the yellow perch stock by only a few percent. However, there are several power plants impacting the yellow perch stock of the western basin of Lake Erie and the combined impact should be examined.

Jensen, A. L., and T. A. Hamilton. 1982. Application of a Conventional Fishery Model for Assessment of Entrainment and Impingement Impact. Environ. Biol. Fish. 7(2): 181-185.

A conventional stock assessment model is applied to determine the impact of entrainment and impingement at the Monroe Power Plant on the yellow perch stock of the Western basin of Lake Erie. Parameters of the model are estimated using power plant data, biological data available in the literature, and commercial catch data. The model is applied to estimate the age structure and biomass of the perch stock and to estimate the impact of the power plant on abundance of the impingeable stock and abundance and biomass of the exploited stock. The level of impact was examined under a range of mortality conditions. Under the most extreme conditions examined of full pumping, high fishing mortality, and low natural mortality, the fishable biomass is reduced by 1.7%. This impact is not large, but there are several other power plants and many additional water intakes around the Western basin of Lake Erie.

Johnson, T. C., J. E. Evans, and S. J. Eisenreich. 1982. Total Organic Carbon in Lake Superior Sediments: Comparisons with Hemipelagic and Pelagic Marine Environments. Limnol. Oceanogr. 27(3): 481-491.

Seventeen box cores from Lake Superior were analyzed for total organic carbon (TOC), porosity, and ^{210}Pb activity. The data were used to determine relationships among bulk sedimentation rates, TOC sedimentation rates, and TOC degradation rates with depth in the core. Results are compared with predictive equations for TOC sedimentation rates and degradation rates in the oceans and show some striking similarities between the behavior of TOC in Lake Superior and in hemipelagic and pelagic marine environments.

Kang, S. W., Y. P. Sheng, and W. Lick. 1982. Wave Action and Bottom Shear Stresses in Lake Erie. J. Great Lakes Res. 8(3): 482-494.

For Lake Erie, the amplitudes and periods of wind-driven, surface gravity waves were calculated by means of the SMB hindcasting method. Bottom orbital velocities and bottom shear stresses were then calculated using linear wave theory and Kajiura's (1968) turbulent oscillating boundary layer analysis. These calculations were made for south-west and north wind directions and a steady wind speed of 40 km hr^{-1}. Calculated bottom shear stresses are related to the textural properties of surficial Lake Erie sediments as determined by Thomas et al. (1976). The bottom shear stresses, especially under prevailing southwest wind conditions, control the textural characteristics of surface sediments in Lake Erie. In particular, wave-induced bottom shear stresses are probably the most important energy source for sediment entrainment.

Kier, L. B., and L. H. Hall. 1982. Structural Influences and Mechanisms of Toxic Effects of Alcohols and Their Derivatives. Bull. Environ. Contam. Toxicol. 29: 121-126.

The simple connectivity index $^{1}\chi$ gives a reasonable account of the variation of potency with molecular structure for each of the cases presented here. The behavior of the alcohols is described better by the simple linear relationship than is the behavior of the xanthates, especially for inhibition of Tubifex worms and fish narcosis. Although a bilinear or nonlinear relationship may give improved description in these cases, lack of data in the region of higher monologs makes such equations difficult to justify on statistical grounds.

The fact that the simple (nonvalence) index gives good correlation suggests that the heteroatoms (alcohol or xanthate group) plays a constant role in the biological processes. Variation in potency arises from variation in alkyl group structure.

Lech, J. J., M. J. Vodicnik, and C. R. Elcombe. 1982. Induction of Monooxygenase Activity in Fish. IN: Aquatic Toxicology (L.J. Weber, ed.), pp. 107-148, Raven Press, New York.

Although the oxidation and conjugation of drugs and xenobiotic chemicals in mammals have been extensively studied in the past, it is only in recent years that attention has been devoted to these phenomena in aquatic species. Catalyzed by a critical need for knowledge concerning the persistence and fate of chemicals in fish and other aquatic species, significant advances in this field have been made of late. It has been firmly established over the past ten years that fish are able to oxidize and conjugate many foreign chemicals, and the biochemical systems responsible for these oxidations and conjugations are qualitatively, if not quantitatively, similar to those found in mammals and avian species. Much of the early work concerning biotransformation systems in fish and other aquatic species was performed in vitro and was largely patterned after early studies done with tissue fractions from a variety of mammalian species. A progression from in vitro studies to in vivo investigations in recent years has provided evidence that biotransformation of many xenobiotic chemicals occurs in the intact fish and that these processes may lead to the formation of more toxic materials, as well as less biologically active products.

In the face of much available information concerning the induction of monooxygenase (MO) by xenobiotic chemicals in mammalian and avian species, literature concerning this phenomenon in fish has only begun to appear in the last few years. The induction of MO activity by several types of chemicals is discussed in this chapter.

Lederman, T. C., and G.-Y. Rhee. 1982. Bioconcentration of a Hexachlorobiphenyl in Great Lakes Planktonic Algae. Can. J. Fish. Aquat. Sci. 39: 380-387.

The bioconcentration of 2,4,5,2',4',5'-hexachlorobiphenyl (HCB) was examined in the Great Lakes algae Fragilaria crotonensis, Ankistrodesmus falcatus, and Microcystis sp. The bioconcentration factors varied from species to species, whether they were expressed in terms of cell number, dry weight, cellular carbon, or cellular lipid. The factors were in the range of 10^5-10^6 and increased with decreasing biomass. The existence of a mucilage layer in F. crotonensis was associated with a twofold increase in the bioconcentration factor. Surface adsorption appeared to contribute only slightly to the bioaccumulation of HCB. HCB desorbed from all species but at a much slower rate than its adsorption.

Lederman, T. C., and G.-Y. Rhee. 1982. Influence of a Hexachlorobiphenyl in Great Lakes Phytoplankton in Continuous Culture. Can. J. Fish. Aquat. Sci. 39: 388-394.

The influence of 2,4,5,2',4',5'-hexachlorobiphenyl (HCB) on the growth of Great Lakes phytoplankters *Fragilaria crotonensis*, *Ankistrodesmus falcatus*, and *Microcystis* sp. was investigated in continuous culture under nutrient-sufficient and phosphate (P) limited conditions. Growth rate (μ) was inhibited only in *F. crotonensis* at cellular HCB concentrations as low as 4 x 10^{-8} ng/cell (0.8 μg/g dry weight) in nutrient-sufficient cultures; there appeared to be a dose-response relationship between cellular HCB and μ. *Microcystis* sp. and *A. falcatus* showed no inhibitory effect at cellular HCB levels up to 5 x 10^{-8} ng/cell (3.6 μg/g dry weight) and 30 x 10^{-8} ng/cell (11.5 μg/g dry weight), respectively. Under P-limited conditions HCB also affected *F. crotonensis* but not *A. falcatus*. The initial response of *F. crotonensis* to HCB addition was a significant increase in μ, followed by a sharp decline. In both nutrient-rich and P-limited *F. crotonensis* the cellular chlorophyll *a* (chl *a*) concentration decreased with the accumulation of HCB, yet the ^{14}C assimilation rate per unit chl *a* increased. Cellular P concentration in the P-limited cells also decreased with the accumulation of HCB. Such responses were not observed in the other species.

Lekan, J. F., and T. A. Coney. 1982. The Use of Remote Sensing to Map the Areal Distribution of *Cladophora glomerata* at a Site in Lake Huron. J. Great Lakes Res. 8(1): 144-152.

The areal distribution of the benthic alga *Cladophora glomerata* and the percent areal coverage of *Cladophora* within 45.8 m (150 ft) by 15.3 m (50 ft) model cells for a 2.8 km length of Lake Huron shoreline at Harbor Beach, Michigan, are determined by remote sensing techniques. Data were acquired on 21 July 1979, a calm, clear day over Lake Huron at an altitude of 305 m with an eleven-channel modular multispectral scanner mounted in a NASA C-131 aircraft. *Cladophora* is determined by a conventional maximum likelihood statistical supervised classification technique employing three of the scanner bands. An intensive field survey of the study site indicated that the computer classified imagery is representative of the *Cladophora* distribution at Harbor Beach. Classification accuracy is not determined because the site was not mapped by ground surveys. The percent of areal coverage of model cells by *Cladophora* ranges from 0% to 93%. Calculations based on these percentages indicate that the alga occupies an area of 38,704 m^2 at the study site. Overlapping flight lines resulted in duplicate measurements of many model cells. The reproducibility of results for these areas is good ($R = 0.86$ and standard error of estimate of 9.9%) when suitable well-defined *Cladophora* training sites are common to adjacent data sets. The reproducibility decreases in the absence of this condition.

Lick, W. 1982. Entrainment, Deposition, and Transport of Fine-Grained Sediments in Lakes. Hydrobiologia 91: 31-40.

Recent work on the settling, diffusion, entrainment, and deposition of fine-grained sediments in fresh water is reviewed and synthesized. Particular attention is given to the dependence of these processes on sediment properties such as particle size. The application of this knowledge to the analysis and numerical modeling of sediment transport is also discussed. Much of the work is concerned with the Great Lakes and, more specifically, with the Western Basin of Lake Erie.

Lick, W. 1982. The Transport of Contaminants in the Great Lakes. Ann. Rev. Earth Planet. Sci. 10: 327-353.

In order to make optimum use of the Great Lakes, the adverse effects of these wastes must be minimized. To do this, one must be able to quantitatively predict the transport, fate, and effects of contaminants in the Great Lakes. This requires an understanding of how and where are contaminants transported, and what are the biochemical transformations affecting this transport. Since most contaminants are associated with particulates, special attention is given to the transport of particulates although similar arguments apply to dissolved substances. To give some indication of how biological and chemical transformations affect the fate of contaminants, a brief discussion of the effects of these transformations on the transport and fate of several important and representative contaminants is given. A thorough discussion of the physical, chemical, and biological factors affecting the transport and fate of all contaminants present in the Great Lakes is beyond the scope of this article and so the discussion is limited to a few contaminants including sediments, radionuclides, phytoplankton, and toxic chlorinated hydrocarbons.

Lima, A. R., C. Curtis, D. E. Hammermeister, D. J. Call, and T. A. Felhaber. 1982. Acute Toxicity of Silver to Selected Fish and Invertebrates. Bull. Environ. Contam. Toxicol. 29: 184-189.

The present study was conducted to expand the data base on the toxicity of silver to aquatic organisms. The following organisms were exposed to silver nitrate in acute toxicity tests: flagfish (Jordanella floridae), fathead minnows (Pimephales promelas), scuds (Gammarus pseudolimnaeus) and parthenogenetic midges (Tanytarsus dissimilis Johannsen, 1937).

LC50 values extended over approximately three orders of magnitude with the four species tested. The 96-h LC50s were 10.7 μg/l for fathead minnows and 9.2 μg/l for flagfish. The 96-h LC50 for scuds was 4.5 μg/l. In order to obtain mortality with midges some concentrations were prepared to exceed the solubility of silver in exposure water. The midges were lightly blanketed with white precipitate and their movements stirred up the precipitate in the three highest (≥1870 μg/l) exposure concentrations. Thus an LC50 value was difficult to obtain.

Lorenz, R. C., and C. E. Herdendorf. 1982. Growth Dynamics of Cladophora glomerata in Western Lake Erie in Relation to Some Environmental Factors. J. Great Lakes Res. 8(1): 42-53.

> Cladophora was monitored at two sites in western Lake Erie during 1979 and 1980 as part of a lake-wide Lake Erie Cladophora Surveillance Program. Two distinctive zones within the littoral region were colonized by the alga, the eulittoral (splash zone) and infralittoral (defined in the present study as the 0.5-4 depth zone). Cladophora of the eulittoral zone became established in May and remained present until late fall. The infralittoral zone Cladophora exhibited a bimodal growth pattern related to the seasonal temperature regime, with growth occurring from April to July and again from September to November. The infralittoral zone supported by the largest share of biomass, which resulted in nuisance accumulations upon the beaches in the island region. Peak biomass was observed from mid-June to early July, obtaining maximum values of 102 gDW/m^2 and 214 gDW/m^2 for the 1979 and 1980 seasons, respectively. The depth to which Cladophora colonized was limited by light availability; maximum depth of growth occurred between 2 and 4 m in western Lake Erie due to the turbid nature of the basin. Phosphorus and nitrogen were not limiting to Cladophora growth in western Lake Erie; tissue nutrients remained above the critical levels defined by Gerloff and Fitzgerald throughout the season.

Loucks, O. L. 1982. The Concern for Acidic Deposition in the Great Lakes Region. IN: Acid Precipitation - Effects on Ecological Systems (F. M. D'Itri, ed.), Chapter 2, pp. 21-41, Ann Arbor Science, Ann Arbor, Michigan.

> The Great Lakes region of the United States and Canada is an especially appropriate focus for acid rain research for one paramount reason: If the evidence is compelling that environmental alterations from acidic deposition could, indeed, be of the type and magnitude being alleged in other regions, then there are urgent decisions and actions needed now to prevent those effects from being expressed here. A principal goal, therefore, must be to review the evidence as it applies to the unaltered, or slightly altered, Great Lakes region, and to consider what new data or relationships still need documentation before mitigation or control strategies can be evaluated. This paper will outline why a lightly impacted region can be so important to the perspectives of both Canada and the United States, and to highlight the implications of certain recent insights on effects processes.

McCormick, J. H., and G. N. Stokes. 1982. Intraovarian Invasion of Smallmouth Bass Oocytes by Proteocephalus ambloplites (Cestoda). J. Parasitol. 68(5): 973-975. ERL-D Reprint #283.

> The bass tapeworm Proteocephalus ambloplites (Cestoda) has long been associated with poor reproduction in bass Micropterus sp. It has been suggested that the prevalence of this parasite in the ovaries of mature bass may be due to the rich blood supply of the ovaries. We suggest

that the nutrients available in maturing oocytes may be at least equally as responsible for the abundance of the parasite in bass ovaries. We further suggest that, in addition to the scar tissue formed by parasitic invasion, direct oocyte destruction may also contribute to reduced production of viable oocytes and subsequent impaired reproductive success. Two photomicrographs are provided to support these beliefs.

McKim, J. M., and H. M. Goeden. 1982. A Direct Measure of the Uptake Efficiency of a Xenobiotic Chemical Across the Gills of Brook Trout Under Normoxic and Hypoxic Conditions. Comp. Biochem. Physiol. 72C(1): 65-74. ERL-D Reprint #270.

1. An *in vivo* whole fish preparation was evaluated for measuring the uptake efficiency of chemicals directly from the water across the gills of transected brook trout. 2. A continuous-flow system allowed a determination of the effects of environmental variables (i.e., dissolved oxygen) on the movement of chemicals across the blood-water interface at the gills. 3. Endrin uptake efficiency at two water concentrations (0.046 and 0.072 μg endrin/l) was 81 ± 9% and 80 ± 8%, respectively, indicating no significant effect of endrin concentration on uptake efficiency. 4. Total mean endrin taken up across the gills (dose) at 11-12°C was ca. 7.1 μg/kg per day at the low endrin concentration and 13.2 μg/kg per day at the high. 5. Mean ventilation volume increased 72 ± 21 ml/min at oxygen saturation to 310 ± 67 ml/min at 30% of saturation substantially increasing endrin exposure to the gills. 6. Oxygen utilization (%) decreased from a mean of 60 ± 11% oxygen saturation to 44 ± 10% at 30% of saturation, while endrin uptake efficiency dropped from a mean of 80 ± 11% at saturation to a low of 47 ± 11% at 30% of saturation. 7. In spite of decreased oxygen utilization (%) and endrin uptake efficiency (%), the total uptake of endrin and oxygen increased as the oxygen content of the water was decreased, to 50% of saturation. 8. A threshold for oxygen and endrin uptake occurred between 50 and 30% of water oxygen saturation beyond which brook trout could no longer increase uptake of oxygen or endrin despite a larger respiratory volume.

McKim, J. M., and R. F. Syrett. 1982. Mobile Surgical Table with Automatic Solenoid System for Fishery Applications. Prog. Fish-Cult. 44(2): 75-78. ERL-D Reprint #277.

A self-contained mobile surgical table for fishery applications is described. An automatic solenoid switching system provides for controlled delivery of anesthetic and anesthetic-free water.

McNaught, D. C. 1982. Overview of Contaminant Interactions with Surface Films, Zooplankton, and Fish. J. Great Lakes Res. 8(2): 358-359.

Surface films contain organic matter, rich in lipids which serves to trap contaminants from the atmosphere. At specific times of the day, surface films may also entrap significant numbers of zooplankton, which presumably were attracted to near-surface food supplies (and may incidentally ingest contaminated organics) and fishes in pursuit of their zooplankton prey. Thus the surfaces of the Great Lakes, as well as of small ponds and the oceans, are relatively rich in both living and decomposing organic matter. Such films are likely microhabitats where lipid-soluble contaminants move with relative ease from one compartment to another in the food web. As such, surface films deserve continued study.

Generally, our attempts at a synthesis relating surface film contaminants to fishes and zooplankton are not as successful as those relating to bacteria and phytoplankton. Ecologists have not carefully considered surface microlayers as habitats for filter-feeding zooplankton and fishes. We might only hope that continued study of dynamic aquatic systems, as outlined in this volume and beginning with the atmospheric input of contaminants like PCBs and terminating with lake trout bearing unacceptable levels, will lead to solutions to the preserving of our Great Lakes and their significant resources for future generations.

McNaught, D.C. 1982. Short Cycling of Contaminants by Zooplankton and Their Impact on Great Lakes Ecosystems. J. Great Lakes Res. 8(2): 360-366.

Field evidence for short cycling of organic contaminants, from sources at the air-water interface directly into the zooplankton and fishes, has generally been lacking in the literature. The potential mechanisms, however, have been intensively explored; these are dominated by the formation of organic platelets at the air-water interface and the availability to grazers of other forms of suspended detritus. Susceptibility of the zooplankton to short cycling of contaminants thus depends upon their demonstrated propensity to feed near the surface of the lakes. As contrasted with missing environmental information, experimental evidence for short cycling is clear; the experimental inclusion of small, organic particles along with natural assemblages of nannoplankton increased PCB loading to the zooplankton 2.3 times. Further field evidence on the magnitude of short cycling must be sought, because contaminants soluble in oils influence the entire food chain. Organic contaminants such as PCBs have two distinct actions upon zooplankton populations, including the reduction of birth rates and the increase in death rates, and the inhibition of ecosystem functions such as feeding.

Moseley, M. A., and E. D. Pellizzari. 1982. Polysiloxane Deactivated Fused Silica Capillaries Containing Immobilized Stationary Phases. J. High Resol. Chromatog. Chromatog. Communic. 5: 472-475.

This article describes a method of preparing immobilized stationary phases which has arisen from the author's work on polysiloxane deactivation of fused silica capillaries. Although acid treatment is often omitted with fused silica capillaries, there are good reasons for hydrothermal treatment of this column material. Use of Grob's peroxide method gave immobilized 0.25 μm films of SE-54; lowering of the immobilization temperature permitted immobilization of 0.1 μm films of the same phase.

Olson, D. L., and G. M. Christensen. 1982. Effect of Selected Environmental Pollutants and Other Chemicals on the Activity of Urease (*in vitro*). Bull. Environ. Contam. Toxicol. 28: 439-445. ERL-D Reprint #268.

Urease was treated *in vitro* with 93 chemicals of various chemical classes in order to study inhibitory effects. The organometallic chemicals, methyl mercuric chloride and phenyl mercuric chloride were the strongest inhibitors studied, about 10^{-7} times more than NaCl. Also highly inhibiting were Hg(II), Ag(I), and Cu(II), followed by IO_4^{-1}, Au(III) and Cd(II). In addition, the anions $Cr_2O_7^{-2}$, F^{-1}, AsO_2^{-1}, and BH_4^{-1} had a moderate effect. No measurable effect was shown by the anions, Br^{-1}, I^{-1}, N_3^{-1}, and S^{-2}. The herbicide, 2,4-D, was found to be the most reactive of the organic chemicals studied, followed closely by sodium dodecylsulfate, 2,2-dichloropropionic acid and p-chloro-benzoic acid. The herbicides derived from urea (diuron, monuron, and fenuron) were found to be unreactive. Of the following multi-valent chemicals tested, selenite was more inhibiting than selenate; Pd(II) more than Pd(IV); arsenite more than arsenate; Cr(VI) more than Cr(III) and Fe(II) more than Fe(III). None of the widely used pesticides such as malathion, captan, diazinon, and carbaryl elicited a measurable effect. Warfarin (rodenticide) and pentachlorophenol (fungicide) caused a mild effect. In two preparations of mixtures made up of ten components each, an approximately 10-fold increase in inhibition was found, indicating that for the chemicals tested, the toxic effect was additive.

Patterson, R. L., and K. D. Smith. 1982. Impact of Power Plant Entrainment of Ichthyoplankton on Juvenile Recruitment of Four Fishes in Western Lake Erie in 1975-77. J. Great Lakes Res. 8(3): 558-569.

The effect of power plant entrainment on juvenile recruitment of four species of ichthyoplankton in western Lake Erie was investigated. Of the four species studied - gizzard shad (*Dorosoma cepedianum*), white bass (*Morone chrysops*), walleye (*Stizostedion vitreum*) and freshwater drum (*Aplodinotus grunniens*) - it was found that the effect on walleye year class strength is minimal while the effect on gizzard shad recruitment may possibly be significant in terms of overall impact on the community ecology of the western basin. This aspect of the impact of power plant entrainment should be further investigated. It was estimated that total juvenile recruitment of these four species would increase by 742 individuals per acre if all power plant entrainment were eliminated.

Paul, J. F., R. Kasprzyk, and W. Lick. 1982. Turbidity in the Western Basin of Lake Erie. J. Geophys. Res. 87(C8): 5779-5784.

Turbidity data from the Oregon, Ohio municipal water intake in the Western Basin of Lake Erie for the years 1976 through 1979 were examined. A relatively simple formula for the turbidity as a function of bottom shear stress due to wave action and sediment loading from the Maumee River was developed. Excellent agreement was found between the observed and calculated turbidities for all years examined. The results demonstrate that (1) turbidity is directly related to wave action and the resulting bottom stress, (2) sediments from the Maumee River significantly contribute to the amount of entrainable sediment near the Oregon intake, (3) the transport of suspended solids from the Maumee River to the Oregon intake as a significant factor in causing high turbidity, and (4) there is reasonable equality between turbidity in NTU units and suspended sediment concentration in units of milligrams per liter.

Phipps, G. L., G. W. Holcombe, and J. T. Fiandt. 1982. Saturator System for Generating Toxic Water Solutions for Aquatic Bioassays. Prog. Fish-Cult. 44(2): 115-116. ERL-D Reprint #276.

An improved saturation apparatus for continuously generating large volumes of water solutions of hydrophobic compounds for conducting aquatic bioassays is described. Closed 19 L stainless steel soda carbonation vessels replace the open glass vessels commonly used. The apparatus has been used successfully with liquid, semi-liquid and solid compounds and has delivered up to 200 ml/min of toxicant ladened water to a test system. The modular design of this saturator makes the flow capacity almost infinite by simply connecting another vessel in line.

Pickering, Q. H., and W. T. Gilliam. 1982. Toxicity of Aldicarb and Fonofos to the Early-Life-Stage of the Fathead Minnow. Arch. Environ. Contam. Toxicol. 11: 699-702. ERL-D Reprint #287.

Flow-through early-life-stage (ELS) toxicity tests were conducted with the pesticides aldicarb (Temik®) and fonofos (Dyfonate®) to determine their effect on the survival and growth of fathead minnows. Concentrations of 78 μg/l of aldicarb and 16 μg/l of fonofos did not affect survival and growth. However, 156 μg/1 of aldicarb and 33 μg/1 of fonofos were lethal to larval-juvenile exposed for 30 days post-hatch. The maximum acceptable toxicant concentration (MATC) of aldicarb and fonofos for the fathead minnow is estimated to be between 78-156 μg/1 and 16-33 μg/1, respectively. The corresponding chronic values (geometric mean of MATC values) would be 110 μg/1 and 23 μg/1. Acute toxicity tests gave 96-hr LC50 values of 1370 μg aldicarb/1 and 1090 μg fonofos/1. The acute-chronic ratio (96-hr LC50/chronic value) is 12 for aldicarb and 47 for fonofos.

Ragland, K. W., and K. E. Wilkening. 1982. Relationship Between Mesoscale Acid Precipitation and Meteorological Factors. IN: Acid Precipitation - Effects on Ecological Systems (F.M. D'Itri, ed.), Chapter 6, pp. 123-139, Ann Arbor Science, Ann Arbor, Michigan.

To justify controls on emissions of acid precursors, the relationship between a particular source and the deposition pattern that it produces needs to be understood. This is difficult to accomplish by field monitoring because monitoring data register many sources, some of which may be hundreds or thousands of kilometers away. Mathematical models are the only way to estimate the relative contribution of difficult sources to the total deposition at a particular receptor.

Atmospheric deposition models may be divided into (1) long-range transport models, where the region of interest extends over thousands of kilometers, say the eastern half of the U.S. and Canada, and (2) mesoscale models where the analysis region extends over hundreds of kilometers. Because mesoscale models can provide higher resolution and more detailed simulation of meteorological conditions, they can predict the influence of a specific emission source on deposition at a nearby receptor point. However, mesoscale models show only incremental changes within the region rather than absolute deposition rates.

The purpose of this chapter is to briefly describe our mesoscale deposition model (UWATM-SOX) and present the results of the application of this model to the Rainy Lake watershed, which is located northwest of Lake Superior. Annual, seasonal, and weekly calculations of sulfate deposition are presented and compared with field monitoring data.

Rhee, G.-Y. 1982. Effects of Environmental Factors and their Interactions on Phytoplankton Growth. IN: Advances in Microbial Ecology (K. C. Marshall, ed.), Vol. 6, pp. 33-74, Plenum Publishing Corp.

The abundance and distribution of phytoplankton in the natural environment are regulated by various environmental factors, such as nutrient, light, and temperature. The effect, or stress, of each factor changes with time and space, and the relative importance of each factor also varies. Sometimes it is not difficult to identify the key factor controlling primary productivity, but quite frequently, it takes laborious efforts to discern the responsible environmental stress. This difficulty is due in good measure to the simultaneous action of more than one stress and is compounded by our general lack of understanding of the way one factor interplays with others in controlling growth.

Species also differ in their responses to environmental stresses, since they have different optimum conditions for growth. These differences are the driving forces responsible for species distribution and succession.

The present chapter will examine the effects of three principal factors - nutrient, light, and temperature - and their interactions on phytoplankton growth. The findings from continuous culture studies have recently been reviewed elsewhere.

Rhee, G.-Y. 1982. Overview of Phytoplankton Contaminant Problems. J. Great Lakes Res. 8(2): 326-327.

There is a multitude of hydrophobic organic pollutants in nature. Ultimately, therefore, their absorption to plankton algae and subsequent biological effects should be understood in terms of this multiplicity; it should be determined whether there are additive, synergistic, or antagonistic relationships among chemicals in their absorption to organisms and biological activities. These effects should also be understood in terms of the unique environmental characteristics such as high light intensities in the surface microlayers, for these photoautotrophs.

Ross, M. J., and C. F. Kleiner. 1982. Shielded-Needle Technique for Surgically Implanting Radio-Frequency Transmitters in Fish. Prog. Fish-Cult. 44(1): 41-43. ERL-D Reprint #264.

Protruding whip antenna radio transmitters were impanted in fish with abdominal pelvic fins. This surgical technique enables the transmitter to be positioned anywhere in the peritoneal cavity without piercing vital organs through the use of a shielded needle to guide an antenna along the intestine under the pelvic girdle. Results of this technique used on several species including some with thoractic ventral fins show that fish lived a minimum of 28 days after implantation, indicating that major damage to the internal organs had not occurred. Best results were obtained when fish were captured, tagged, and returned to open water.

Ross, M. J., and D. B. Siniff. 1982. Temperatures Selected in a Power Plant Thermal Effluent by Adult Yellow Perch (Perca flavescens) in Winter. Can. J. Fish. Aquat. Sci. 39: 346-349.

Winter-temperature selection by yellow perch (Perca flavescens) was monitored by radio telemetry near the thermal discharge from a power plant on the Upper Mississippi River. Ten fish were equipped with temperature-sensing radio transmitters. Temperature selection was monitored with an automatic recording system and manually with standard radio frequency receivers. The selected mean winter temperature for all locations was 5.4°C; when fish were in the discharge area mean temperature selected was 6.3°C. Ninety-one percent of the temperatures were recorded from fish in the discharge bay. Response to temperature varied greatly among individual fish, and they selected significantly lower temperatures in the field than in laboratory experiments. These field-selected temperatures correspond closely to those required for gametogenesis and spawning success in these species.

Schultz, T. W., L. B. Kier, and L. H. Hall. 1982. Structure-Toxicity Relationships of Selected Nitrogenous Heterocyclic Compounds. III. Relations Using Molecular Connectivity. Bull. Environ. Contam. Toxicol. 28: 373-378.

The objective of this investigation was to examine the QSAR between cellular response and molecular connectivity indexes for a series of 24 mono- and dinitrogen heterocyclic compounds that increase in ring attachment and methyl substitution, and that have possible isomeric differences. The Chemical Abstract Service registry number, ${}^1\chi^v$ molecular connectivity index, log BR observed, log BR predicted, and residual value for each test chemical were compared. Previous work demonstrating that toxicity increased with an increase in the number of atoms and degree of methylation per compound and that toxicity decreases with an increase in nitrogen substitution was corroborated. However, the present study gives an improved correlation coefficient of $r = 0.962$.

Shubat, P. J., S. H. Poirier, M. L. Knuth, and L. T. Brooke. 1982. Acute Toxicity of Tetrachloroethylene and Tetrachloroethylene with Dimethylformamide to Rainbow Trout (Salmo gairdneri). Bull. Environ. Contam. Toxicol. 28: 7-10.

In this study, two acute toxicity tests were conducted with tetrachloroethylene (TCE) using rainbow trout. DMF was used as an additive in one of the tests and was proportionally diluted with the toxicant. The 96-hr LC50 was 4.99 mg/l in the test without DMF and 5.84 mg/l for DMF and TCE.

Sicko-Goad, L. 1982. A Morphometric Analysis of Algal Response to Low Dose, Short-Term Heavy Metal Exposure. Protoplasma 110: 75-86.

Three algae, Melosira granulata, Fragilaria capucina, and Anacystis cyanea, collected as part of a natural phytoplankton assemblage were found to differ in their cytological responses to low dose short-term exposure to copper and lead. In general, all were more sensitive to copper than to lead. Fragilaria was more sensitive to both metals than the other species examined. Most immediate changes in relative volume categories can be ascribed to changes in vacuole volume that are most likely the result of changes at 24 hours. These results are discussed in view of the natural environment of the algae, as well as in relationship to previous studies.

Snarski, V. M. 1982. The Response of Rainbow Trout Salmo gairdneri to Aeromonas hydrophila After Sublethal Exposures to PCB and Copper. Environ. Pollut. (Series A) 28: 219-232. ERL-D Reprint #274.

Rainbow trout were continuously exposed to sublethal PCB concentrations of 7.3 and 14.7 μg $litre^{-1}$ for 30 days and infected with A. hydrophila or sham-injected. Mortality of PCB-exposed infected fish was significantly lower than control-infected fish. Survivors of the infection at all exposure concentrations had elevated leucocrits and decreased haematocrits compared with their respective shams. PCB-exposed sham fish had significantly higher leucocrits at both concentrations and significantly lower haematocrits at 14.7 μg $litre^{-1}$ compared with control-shams. Among the infected fish, leucocrits at both PCB concentrations were higher than the control, but haematocrits were not different at any concentration.

No significant adverse effects on rainbow trout of copper at 10.9 and 21.5 μg $litre^{-1}$ were found in a similar 30-day exposure - A. hydrophila infection study. Mortality of Cu-exposed infected fish was not different from that in control-infected fish and haematocrits and leucocrits showed no significant differences related to copper concentration.

Snarski, V. M., and G. F. Olson. 1982. Chronic Toxicity and Bioaccumulation of Mercuric Chloride in the Fathead Minnow Pimephales promelas. Aquat. Toxicol. 2: 143-156. ERL-D Reprint #266.

Fathead minnows (Pimephales promelas) were exposed to various concentrations of mercuric chloride in water to determine its acute and chronic (including reproduction) toxicity and to measure bioaccumulation. Mean LC50 values of $HgCl_2$ for juvenile fatheads were 168, 112, 84, and 74 μg Hg/l at 4, 5, 6, and 7 days, respectively. Following 41 wk of exposure to 0.26 to 3.69 μg/l, females were significantly smaller than controls at all concentrations except 0.50 μg/l and males showed reduced growth at 3.69 μg/l. Over half of the fish at 2.01 and 3.69 μg/l were severely stunted and scoliosis was prevalent among these stunted fish. No spawning occurred at and above 1.02 μg/l and the number of spawning pairs was reduced at 0.26 and 0.50 µg/l resulting in total egg production of 46 and 54%, respectively, of control. Thirty-day growth of second-generation larvae (from transferred control embryos at and above 1.02 µg/l) was significantly reduced at all mercury concentrations tested. No effects on hatchability or larval survival was detected. Chronically-exposed fish accumulated mean whole body total mercury residues of 1.36 to 18.80 µg/g of tissue (wet weight) from 0.26 to 3.69 µg/l, respectively. Uptake appeared proportional to water concentration; bioconcentration factors varied between 4,380 and 5,680.

The influence of diet on mercury toxicity and bioaccumulation was studied during two 60-day larval fathead exposures. Overall reduced growth and possibly enhanced toxic effects occurred in larvae on the dry trout starter diet compared to larvae fed on _Artemia_. Mercury uptake appeared influenced by the severity of toxic effects.

Spehar, R. L., G. M. Christensen, C. Curtis, A. E. Lemke, T. J. Norberg, and Q. H. Pickering. 1982. Effects of Pollution on Freshwater Fish. J. Water Pollut. Control Fed. 54(6): 877-922. ERL-D Reprint #269.

A review of the 1981 world literature was conducted on the effects of pollution on freshwater fish. This review contained 353 references and included papers on water quality such as dissolved gases and pH; chemical pollutants such as insecticides, herbicides, piscicides and anesthetics; inorganics, organics and industrial and municipal effluents including chlorine and wastewater and pulp and paper. Papers from reviews and symposia and those dealing with physical factors were also included. Within the above sections, papers were organized into general articles, surveys, toxicology, bioaccumulation, physiology and behavior.

Spehar, R. L., D. K. Tanner, and J. H. Gibson. 1982. Effects of Kelthane and Pydrin on Early Life Stages of Fathead Minnows (_Pimephales promelas_) and Amphipods (_Hyalella azteca_). IN: Aquatic Toxicology and Hazard Assessment: Fifth Conference, ASTM STP 766 (J. G. Pearson et al., eds.), pp. 234-244, Am. Soc. Test. Mater. ERL-D Reprint #272.

Embryonic, larval and early juvenile stages of fathead minnows (_Pimephales promelas_) and juvenile amphipods (_Hyalella azteca_) were exposed to Kelthane, and fathead minnows were exposed to Pydrin in a small self-contained continuous-flow diluter system for approximately 30 days. Survival of the newly hatched larvae was found to be the most sensitive measure of the effect on fathead minnows of both pesticides. Pydrin was approximately 90 times more toxic to fathead minnows than Kelthane. The lowest effect concentrations of Kelthane and Pydrin were 13 times lower than the 96-h median lethal concentration (LC50) values for fathead minnows exposed in Lake Superior water. The upper and lower chronic limits for Kelthane were 39 and 19 µg/l for fathead minnows and

33 and 19 μg/l for amphipods. The chronic limits for Pydrin and fathead minnows were 0.43 and 0.33 μg/l. The mean bioconcentration factors (BCFs) for Kelthane were 3,700 with fathead minnows and 10,000 with amphipods. The mean BCF for Pydrin with fathead minnows was 3,200. Residue concentrations and BCFs for both pesticides increased with increased water concentrations.

Stephan, C. E. 1982. Increasing the Usefulness of Acute Toxicity Tests. IN: Aquatic Toxicology and Hazard Assessment: Fifth Conference, ASTM STP 766 (J.G. Pearson et al., eds.), pp. 69-81, Am. Soc. Test. Mater. ERL-D Reprint #273.

The conceptually and practically simple acute toxicity test provides information that is useful in the protection of aquatic life from pollution. Standardization increases the usefulness of routine acute tests by increasing their quality and comparability and allowing the study of various aspects of acute toxicity. For example, available data show that for certain materials some species of aquatic animals are at least 5,000 times more acutely sensitive than other species, whereas for other materials the range of acute sensitivity is less than a factor of 50. Various theoretical interpretations of the relationship of toxicity to time within a test have been proposed to improve the usefulness of the acute test, but such theories have not been supported by adequate pertinent data. The usefulness of routine acute toxicity tests can be increased, however, by basing the results not on one effect or another but on a combination of all severe adverse effects, such as death, immobilization, and loss of equilibrium.

Stevenson, R. J., and E. F. Stoermer. 1982. Abundance Patterns of Diatoms on Cladophora in Lake Huron with Respect to a Point Source of Wastewater Treatment Plant Effluent. J. Great Lakes Res. 8(1): 184-195.

Epiphytic diatoms on Cladophora were collected from July to September, 1979, at various distances from a point source of municipal wastewater treatment effluent to Lake Huron. Diatom accumulation rates were positively related to distance from the point source. Despite higher nutrient concentrations nearest the point source, low accumulation rates of Cladophora-epiphyte assemblage biomass and epiphytic diatoms indicated moderate growth inhibition by an undetermined factor. Evaluation of epiphytic diatom population abundance and ecology plus diatom taxocene species diversity supported our conclusions. A curvilinear relationship between diatom species diversity and impacts of growth inhibition is proposed and discussed. The diatom proportion of Cladophora-epiphyte assemblage biomass was positively related to distance from the point source of sewage effluent.

Stevenson, R. J., and E. F. Stoermer. 1982. Luxury Consumption of Phosphorus by Benthic Algae. BioScience 32(8): 682-683.

The ability of algal species to sequester phosphorus in their natural environment was evaluated. The amount of P sequestered was estimated by the density by polyphosphate (polyP) bodies within the cell. The abundance of polyP bodies was related to ambient P concentrations and tissue P.

Stevenson, R. J., and E. F. Stoermer. 1982. Luxury Consumption of Phosphorus by Five *Cladophora* Epiphytes in Lake Huron. Trans. Am. Microsc. Soc. 101(2): 151-161.

The stainable polyphosphate bodies in five species of algae epiphytic on *Cladophora glomerata* were enumerated. The algal populations, two species of diatoms, two species of blue-green algae, and a red alga, were collected at various distances from a point source of phosphorus enrichment in Lake Huron. Populations assayed had accumulated polyphosphate bodies and exhibited different levels of maximum polyphosphate body abundance. Numbers of polyphosphate bodies per unit cell volume were least in the diatoms, greatest in the blue-greens, and intermediate in the red alga. No significant differences were found between subpopulations of the same species growing in different portions of the epiphyte community matrix at one location. The subpopulation growing at the location farthest from the point source of phosphorus had substantially fewer polyphosphate bodies than subpopulations of the same species closer to the point source.

Stevenson, R. J., and E. F. Stoermer. 1982. Seasonal Abundance Patterns of Diatoms on *Cladophora* in Lake Huron. J. Great Lakes Res. 8(1): 169-183.

Rocks bearing *Cladophora* were collected from May to November 1979 at two locations near Harbor Beach, Michigan, in Lake Huron to document seasonal patterns of epiphytic diatom abundance and diatom proportion of the *Cladophora*-epiphyte assemblage biomass in an area receiving effluent from a municipal wastewater treatment plant. Data were examined for evidence of interactions between epiphytic diatoms and *Cladophora*.

Cladophora first appeared in May at which time epiphytic diatoms comprised about 30% of the *Cladophora*-epiphytic assemblage biomass. *Cladophora* growth was greatest in June and July accumulating much faster than diatoms. Peak *Cladophora*-epiphyte assemblage biomass was maintained from July to September. *Cladophora* biomass apparently decreased after August while diatom abundance increased to a September maximum. Diatoms were responsible for the sustained peak of *Cladophora*-epiphyte assemblage biomass as diatoms comprised over 60% of the assemblage biomass in September. The *Cladophora*-epiphyte assemblage collapsed by October.

Low diversity of the epiphytic diatom taxocene and low diatom proportion of the Cladophora-epiphyte assemblage biomass indicated Cladophora may have outcompeted diatom epiphytes during the June-July Cladophora growth pulse. Subsequently epiphytic diatoms may have enhanced Cladophora sloughing by shading and successful nutrient competition.

Taylor, D. R., M. A. Tompkins, S. E. Kirton, T. Mauney, D. F. S. Natusch, and P. K. Hopke. 1982. Analysis of Fly Ash Produced from Combustion of Refuse-Derived Fuel and Coal Mixtures. Environ. Sci. Technol. 16(3): 148-154.

Mixtures of coal and refuse-derived fuel (RDF) were burned and the fly ash was collected and analyzed for concentration trends with respect to RDF/coal ratio and particle size. RDF contributes more Cs, Mn, Sb, and Pb to the fly ash while coal contributes greater amounts of As, Br, Fe, Hf, Ni, Sc, V, and the rare earths. Smaller particles in the RDF fly ash had higher concentrations of As, Cd, Ga, K, Na, Sb, and the rare earths. RDF fly ash contains four distinct morphologies, exhibits a high specific surface area, and does not resemble fly ash derived from a conventional coal-fired power plant. The morphology of the ash helps explain the high solubility of many species in the RDF-rich fractions.

Theriot, E., and E. F. Stoermer. 1982. Observations on North American Populations of Stephanodiscus (Bacillariophyceae) Species Attributed to Friedrich Hustedt. Trans. Am. Microsc. Soc. 101(4): 368-374.

Stephanodiscus alpinus is moderate in diameter, concentrically undulate and heavily silicified. Spine placement on valves from North American populations is variable and may differ from European material. North American specimens also tend to be more coarsely fasciculate. Stephanodiscus tenuis is distinguished by a rosette of areolae in the valve center. Stephanodiscus dubius is heavily silicified and concentrically undulate. The presence of alveoli near the margin of S. dubius distinguishes it from other Stephanodiscus species.

Thomann, R. V. 1982. Verification of Water Quality Models. J. Environ. Eng. Div., Proc. Am. Soc. Civil Eng. 108(EE5): 923-940.

The basic concepts of water quality models are reviewed and the need to recognize calibration and verification of models with observed data is stressed. Post auditing of models after environmental control procedures are implemented is necessary to determine true model prediction ability. The direct questions in the decision-making arena related to model credibility are examined by several quantitative measures of model performance: regression analysis between observed and computed values, relative and root mean square errors and comparison of means. An analysis of 15 DO water quality models indicated median relative error of 10%. For a eutrophication model of Lake Ontario, application of quantitative verification measures indicated the credibility of the calculations decreased as the model was applied to smaller scale phenomena. Inclusion of more complex kinetics reduced median relative error across five variables and over a 10 year modeling framework from 32% to 22%. It is suggested that quantitative measures of water quality model credibility be integrated into the modeling analysis whenever possible.

Thompson, K. W., M. L. Deaton, R. V. Foutz, J. Cairns, Jr., and A. C. Hendricks. 1982. Application of Time-Series Intervention Analysis to Fish Ventilatory Response Data. Can. J. Fish. Aquat. Sci. 39: 518-521.

The development of environmental monitors based on ventilation behavior of fishes has produced large masses of data for which no standard analytical procedures exist. This report demonstrates the application of time-series models to this type of data. It also demonstrates the use of intervention analysis to determine the reaction to changes in water quality. Intervention analysis is a powerful statistical tool that allows for great flexibility in the type of response that can be investigated. In this report it is used to determine the ventilatory reaction of the bluegill (Lepomis macrochirus) to sublethal concentrations of zinc sulfate applied in fluctuating intermittent exposures.

Young, T. C., and J. V. DePinto. 1982. Algal-Availability of Particulate Phosphorus from Diffuse and Point Sources in the Lower Great Lakes Basin. Hydrobiologia 91: 111-119.

Control of phytoplankton production in the Great Lakes can be achieved most efficiently by limiting inputs of biologically available P. We report the results of studies performed to characterize the chemical forms and availability to particulate P in wastewater and tributaries which enter the lower Lakes, the eroding bluffs which border Lake Erie, and bottom samples from the near-shore of western Lake Erie. Rates of release of available P were estimated from a simple first-order model of the process, as observed during algal bioassays. Available P in wastewater samples, as a fraction of total particulate P, was affected minimally by wastewater treatment, including chemical precipitation and filtration; it correlated well with levels of total particulate P. Available particulate P levels in fluvial suspended sediments showed regional uniformity, but appeared to be strongly dependent on levels of both NaOH-P and CDB-P. Rates of release of available P decreased during wastewater treatment to values which were similar in magnitude to those observed for fluvial sediments. Release rates, however, were not related to any of the particulate P fractions which were measured. Analysis of the bluff and bottom samples indicated that P availability in the former was negligible, but the latter contained levels which approached those of wastewater particulates, though available P was released from the bottom sediments at relatively low rates.

Young, T. C., J. V. DePinto, S. E. Flint, M. S. Switzenbaum and J. K. Edzwald. 1982. Algal Availability of Phosphorus in Municipal Wastewater. J. Water Pollut. Control Fed. 54(11): 1505-1516.

This investigation focused on the availability of soluble and particulate phosphorus in wastewater to the alga, Scenedesmus sp. Replicated bioassays were conducted on wastewater samples taken from various locations along the treatment stream at four municipal plants in the vicinity of the Great Lakes. The results showed an average of 55 and 82% of the total particulate and soluble phosphorus was available during short-term (14-day) incubation. The total short-term available phosphorus averaged 72% of the total wastewater phosphorus. Based on a first-order model of the process of converting potentially available to available phosphorus, the average rates of availability of particulate and soluble wastewater phosphorus were similar at 0.27/d, although among samples the rates were not correlated. Ultimate amounts of available phosphorus, estimated from experimental data and the first-order model, showed that all of the soluble and 63% of the particulate phosphorus eventually could be available from the wastewater samples. Wastewater treatment methods at the four municipal plants including chemical precipitation had little selectivity for available to the exclusion of nonavailable phosporus, when considering either short-term (14-day) or long-term (ultimate) availability. The rate of availability, however, did show a trend toward lower values through the treatment systems for both soluble and particulate fractions of phosphorus.

EPA RESEARCH REPORTS

Carlson, A. R., J. A. Tucker, V. R. Mattson, G. L. Phipps, P. M. Cook, G. F. Olson, and F. A. Puglisi. 1982. Cadmium and Endrin Toxicity to Fish in Waters Containing Mineral Fibers. U.S. Environmental Protection Agency, Duluth, Minnesota, Publication No. EPA-600/3-82-053. 32 pp. Project Summary No. EPA-600/S3-82-053.

Taconite tailings and their component asbestiform minerals in Lake Superior water had no demonstrable effect on the chronic toxicity of cadmium to the flagfish, Jordanella floridae. Maximum acceptable toxicant concentrations determined in life cycle tests, were effects on survival, growth, reproduction, and bioconcentration were used as endpoints, were between 3.3 to 7.4, 3.0 to 6.5, and 3.4 to 7.3 μg cadmium/l at 0.004, 0.008, and 0.95 mg/l taconite tailings concentrations, respectively. Similarly, in two tests (A and B) exposing recently hatched fathead minnows, Pimephales promelas, for 45 days to several concentrations of endrin, taconite tailings had no observable effect on survival, growth and bioconcentration. No observable effect concentrations (NOEC(s)) for endrin at 0.02 mg/l taconite tailings concentration were between 0.30 and 0.60 μg/l for group A fish and 0.15 μg/l for group B fish. At 0.05 mg/l taconite tailings concentration, the NOEC(s) were between 0.30 and 0.60 μg/l for group A fish and 0.15 and 0.30 μg/l for group B fish. At 0.95 mg/l taconite tailings concentration the NOEC(s) were between 0.15 and 0.30 μg/l for group A fish and 0.30 and 60 μg/l for group B fish.

DeWinkel, C. C. 1982. An Assessment of Wind Characteristics and Wind Energy Conversion Systems for Electric Utilities: Wisconsin Power Plant Impact Study. U.S. Environmental Protection Agency, Duluth, Minnesota, Publication No. EPA-600/3-82-066. 163 pp. Project Summary No. EPA-600/S3-82-066.

This study assesses the potential contribution of wind energy conversion systems (WECS) to the generation of electricity by utilities in Wisconsin and parts of adjacent states. The final report contains a review of the literature on wind and wind machines, an analysis of wind characteristics in Wisconsin and adjoining areas, and an analysis of WECS applied to the Dairyland Power Cooperative (DPC), a rural-based cooperative serving parts of Wisconsin, Minnesota, Iowa, and Illinois.

Along the shorelines of the Great Lakes, wind energies are among the highest in the U.S. Inland, wind energies in many areas are suitable for WECS; however, careful study is required to select the most favorable sites. The DPC, with its many small, scattered users, is the type of utility for which wind systems are ideally suited. Peak winds correspond with the utility's winter peak loads for electric heating. An economic analysis indicates that WECS can be economically feasible for DPC in the 1980s. The analysis considers WECS only as peak load fuel-savers; if their role in contributing to base-load generating capacity were included, the economic feasibility would be even greater. Combined with a controlled load of water heaters, WECS would lend diversity and stability to the power system and delay or eliminate the need for more costly additions to generating capacity.

A detailed reliability and cost product analysis of WECS plus direct control of a variety of loads, as well as a thorough wind survey, is required for accurate evaluation of any application of wind systems. A model for such analysis is presented in this report.

Fullen, D. J., J. S. Gulliver, and H. G. Stefan. 1982. Photosynthesis and Respiration Rates in the Monticello Experimental Streams: 1976/77 Diel Field Data and Computed Results. U.S. Environmental Protection Agency, Duluth, Minnesota, Publication No. EPA-600/3-82-065. 175 pp. Project Summary No. EPA-600/S3-82-065.

Two-station diel dissolved oxygen measurements collected during 1976-77 at the Monticello Ecological Research Station (Monticello, MN) were analyzed by a graphical-analytical method and by a computer model, Dissolved Oxygen Routing Model (DORM), to determine daily community respiration and photosynthesis. A third set of values was generated by using the DORM model to simulate the graphical method. The complete DORM included surface oxygen exchange, longitudinal dispersion, a higher-order curve extrapolation between upstream dissolved oxygen measurements, and the dependence of respiratory rate on water temperature and dissolved oxygen concentrations: however, neither the graphical nor the simulated graphical models included these factors. The complete DORM gave consistently higher rates of respiration and photosynthesis than either the graphicalanalytical method or the computer simulation.

Gulliver, J. S., T. W. Mattke, and H. G. Stefan. 1982. Numerical and Graphical Procedures for Estimation of Community Photosynthesis and Respiration in Experimental Streams. U.S. Environmental Protection Agency, Duluth, Minnesota, Publication No. EPA-600/3-82-052. 122 pp. Project Summary No. EPA-600/S3-82-052.

> A numerical dissolved oxygen (D.O.) routing model DORM is developed to determine total stream community photosynthesis (P) and community respiration rates (R) through successive routing of two-station diel D.O. measurements in a stream. The model differs from existing procedures for diel curve productivity analysis in that it uses the complete D.O. transport equation, including D.O. surface exchange, longitudinal dispersion, dependence of respiratory rates on water temperature and D.O. The model is applied to the experimental field channels at the USEPA Monticello Ecological Research Station to compute P and R values at different seasons and under different water temperature, solar radiation, and pH conditions. A sensitivity analysis shows that computed P and R values are most sensitive to residence times and surface oxygen exchange (reaeration) coefficients. New equations for surface exchange, including the effect of wind, have been developed and are summarized.
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> A graphical, simplified routing procedure produced P and R values which were 82 and 89 percent, respectively, of those obtained by complete routing, with a standard deviation of less than 5 percent. Nighttime longitudinal D.O. gradients were used to derive respiration rates, R.
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> Maximum values of P and R in the MERS channels were 14.8 g m^{-2} day^{-1} and 10.7 g m^{-2} day^{-1}, respectively. P/R ratios ranged from 0.3 to 2.1. A seasonal dependence of P and R values was found, as expected.
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> Hysteresis in plots of hourly P versus photosynthetically active radiation (PAR) intensity was observed frequently. It was of such magnitude that it could not be caused by errors in surface exchange estimates or other physical processes.

Jensen, A. L., and T. A. Hamilton. 1982. Impact of a Once Through Cooling System on the Yellow Perch Stock in the Western Basin of Lake Erie. U.S. Environmental Protection Agency, Duluth, Minnesota, Publication No. EPA-600/3-82-072. 71 pp. Project Summary No. EPA-600/S3-82-072.

> Conventional stock assessment models have been applied to determine the impact of entrainment and impingement at the Monroe Power Plant on the yellow perch stock of the western basin of Lake Erie. First the surplus production model was applied. Biological parameters of the model were estimated from commercial catch and effort data, and entrainment and impingement coefficients were estimated from power plant data. The model was used to estimate stock biomass, egg production, and larvae production; the proportions entrained and impinged were then estimated.

The impact of water withdrawal on the equilibrium standing stock and maximum sustainable yield from the fishery were estimated and the impacts of increased water withdrawal were simulated.

An analytical model was also applied. Parameters of the analytical model were estimated using power plant data, biological data available in the literature, and commercial catch data. The model was used to estimate the age structure and biomass of the perch stock and to estimate the impact of the power plant on abundance of the impingeable stock and biomass of the exploited stock. The level of impact was examined under a range of mortality conditions. The two models are much different in terms of mathematical structure and in terms of the data applied for estimation of parameters, but give similar estimates of impact of about a 1% to 3% reduction in the size of the exploited stock.

Koenst, W. M., and L. L. Smith, Jr. 1982. Factors Influencing Growth and Survival of White Sucker, *Catostomus commersoni*. U.S. Environmental Protection Agency, Duluth, Minnesota, Publication No. EPA-600/3-82-051. 39 pp. Project Summary No. EPA-600/S3-82-051.

Growth responses of the white sucker, *Catostomus commersoni*, were examined in relation to the influence of temperature, body size, season, daylength, light intensity, food ration level and food quality. Sucker growth was maximum at a temperature range of 19-26°C, depending upon experimental conditions. Fish reared under low light intensities grew an average 43% faster than those reared under unshaded conditions. Growth on various diets was best on live tubificid worms presented over sand substrate > tubificids (no soil substrate) > frozen *Daphnia* > Oregon Moist Pellets > Glencoe Mills pellets. The optimum temperature for growth on excess rations of live tubificids was 25°C and was 19°C on restricted rations (1.5% fish body dry weight). Maximum specific growth rate decreased nearly 4-fold over a size range of 12 to 175 g, but no difference in optimum temperatures was found. Fish of the same approximate size grew twice the rate in the spring as compared to other times of the year. Photoperiod showed little influence on growth rate, but fish exposed to shorter daylength showed a marked increase in time to achieve a maximum growth rate.

The ultimate upper incipient lethal temperature (UUILT), determined by slowly increasing (0.5°C/day) acclimation temperature to death, was 32.5°C for juvenile white suckers and 31.5°C for adults. The UUILT was 2-3°C higher than the upper lethal temperatures measured by the classical approach involving the direct transfer technique.

Liss, W. J., D. M. Woltering, S. E. Finger, M. L. Kulbicki, and B. McClurken. 1982. Organization and Adaptation of Aquatic Laboratory Ecosystems Exposed to the Pesticide Dieldrin. U.S. Environmental Protection Agency, Duluth, Minnesota, Publication No. EPA-600/3-82-050. 110 pp. Project Summary No. EPA-600/S3-82-050.

A system of generalizations pertaining to the organization, development and persistence, adaptation, and productivity of ecological systems and their response to toxic substances was formulated. Laboratory ecosystems composed of persistent populations of guppies, amphipods, snails and various microinvertebrates were used in examining the system of generalizations for their utility and conformity with observation. Guppy populations in the ecosystems were exploited at different rates to simulate fishing, and the systems were provided with different levels of habitat availability and energy input rates.

The laboratory communities developed different steady-state structures at different guppy exploitation rates and different levels of habitat availability and energy input. Guppies, amphipods, and snails were competitors for a common food resource, organic matter derived in part from the primary energy source, an alfalfa ration. Amphipods were also a prey of the guppies. Changes in exploitation rate and habitat availability and energy input brought about changes in the densities of all these interacting populations.

Aquarium experiments intended to evaluate the effects of dieldrin on guppy life history patterns were conducted in conjunction with the laboratory ecosystem studies. This provided the opportunity for examining some of the relationships between effects observed in experiments more like simple toxicity tests and effects observed in laboratory ecosystems. In the aquarium experiments, concentrations of dieldrin similar to those used in the laboratory ecosystems had effects on life history patterns similar to effects on life history patterns observed in the ecosystems. It is less evident how the diversity of effects on guppy populations observed in the ecosystems -- ranging from perturbation and recovery to extinction -- could have been predicted from the aquarium experiments.

Martinson, R. J., E. A. Bergey, and J. V. Ward. 1982. Spring and Springbrook Fauna of the Piceance Basin, Colorado. U.S. Environmental Protection Agency, Duluth, Minnesota, Publication No. EPA-600/3-82-071. 34 pp. Project Summary No. EPA-600/S3-82-071.

The aquatic macroinvertebrates of Willow Creek, Piceance Creek, Stewart Gulch, and of spring sources surrounding Tract C-b in the Piceance Basin were sampled from July 1978 through August 1980 as part of a baseline monitoring program prior to oil-shale development. The spring sources exhibited a somewhat different and more constant physical and chemical environment than the streams. The more constant conditions in the springs allowed a generally greater density and biomass of macroinvertebrates than did the other study streams. Species compositions were also different. Differences in the macroinvertebrate community structure at each of the sites in the streams, were apparently caused by differences in flow patterns, substrate type, and influence of spring sources. The spring sources had distinct communities despite generally similar environmental conditions. Different slopes of the springs were the eminent cause of macroinvertebrate differences between springs. A discussion of major potential impacts resulting from development of oil-shale upon aquatic macroinvertebrates in springs and springbrooks surrounding mining Tract C-b is presented.

Mount, D. I. 1982. Research Progress on Ecotoxicology. Part 1 - Single Species Tests. IN: Research on Fish and Wildlife, pp. 143-149, EPA-600/8-82-022, U.S. Environmental Protection Agency, Office of Research and Development, Washington, D.C.

While research on and testing of single species have involved (in varying degrees) wild mammals, reptiles, and amphibians, most effort has been directed towards aquatic life and birds. Far more environmental toxicology resources have been expended on aquatic life, perhaps because early environmental control efforts almost exclusively focused on water pollution abatement. Only more recently have air and terrestrial pollution abatement become increasingly important. Undoubtedly, the rather high exposure to direct spraying and runoff made them among the first to show obvious harm.

Highlights from the 1970s decade of progress in single species testing are concentrated mainly on aquatic life and to a lesser extent on birds. Many of the future milestones achieved will probably occur in wild mammal and other terrestrial groups if present trends in atmospheric pollution (such as acid rain) continue.

Tibbitts, T. W., S. Will-Wolf, D. F. Karnosky, and D. M. Olszyk. 1982. Impact of Air Pollution on Vegetation Near the Columbia Generating Station. U.S. Environmental Protection Agency, Duluth, Minnesota, Publication No. EPA-600/3-82-068. 212 pp. Project Summary No. EPA-600/S3-82-068.

The impact of air pollution from the coal-fired Columbia Generating Station upon vegetation was investigated. Air monitoring of O_3 and SO_2 documented levels that occurred before and with operation of the generating station. Field sampling of alfalfa, lichens, and white pines was undertaken before and after initiation of generating station operations.

Controlled environmental exposures were undertaken with separate cultivars of crop species grown in the vicinity of the generating station. Alfalfa, carrots, mint, peas, beans, and trembling aspen were

exposed to SO_2 and O_3 to establish minimum threshold pollutant levels for injury from these pollutants. None of the species were found to have threshold levels below the concentrations of SO_2 recorded around the generating station and only trembling aspen was found to have a threshold level for injury that was less than the concentrations of O_3 recorded around the generating station. All species were found to be injured at lower concentrations of SO_2 in combination with O_3 than with SO_2 or O_3 exposures alone. Only trembling aspen was injured by a combination of SO_2 plus O_3 that was less than the levels of these combined pollutants monitored around the generating station. Injury symptom development is described and illustrated for SO_2 and O_3 upon the separate plant species.